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CROSS-POLLINATION OF SUGAR CANE.

By H. B. COWGILL, Plant Breeder, Insular Experiment Station.

Sugar cane has been propagated from seed and the seedlings selected for the purpose of originating new varieties since 1887. This was begun in Java and in Barbados at about the same time, and it has since been taken up in nearly all the cane-producing countries of the world. Originally no record was made of the parentage of the seedlings, and in many cases not even the name of the seed parent was kept. Some very good varieties were originated by this method.

For commercial purposes cane is propagated asexually by cuttings. When it is propagated from seed the variation in the resulting generation, even from a single parent variety, is considerable. It is presumed that some, if not all, of the varieties are more or less heterozygous. It seems nevertheless desirable, in many cases, to make controlled crosses in order to combine such characters as vigor and disease resistance of certain varieties with the good qualities of other kinds.

METHOD OF CROSSING.

It would, of course, be desirable to eliminate all possibility of self-pollination. Attempts to emasculate the florets have been made, and a few seedlings have been produced in Barbados in that way, though, according to Bovell, the number of seedlings produced in any single season has been small. The work is very tedious, for the reason that rets are small and the panicle is brittle. The latter is also produced at 10 to 15 feet from the ground, so that it is necessary to do the hybridizing on a scaffold and sometimes the wind makes the work very difficult.

Kobus (4),[1] in Java, planted a pollen-sterile variety on the lee-
Another method reported by Bovell (1) to be employed in Barbados is to plant two varieties which flower at the same time in alternate stools, called "checkerboard system," for the purpose of facilitating natural cross-pollination. It is, of course, impossible to form any conclusion as to the extent to which crossing takes place with the method, unless the type of seedlings produced by each variety when growing separately is known.

Two additional methods are described by Wilbrink and Ledeboer (6). By the first method the tassels of the variety to be used as the male parent are cut off and tied in position with the one to be used as seed parent. For protection against undesired pollen a screen is provided, having an opening on the leeward side for the entrance of the tassels. By the second method the pollen of the desired variety is collected and carried to the one to be used as the female parent. This latter method is also one which was suggested by D'Albuquerque (3). It is reported that the pollen adheres in masses, and also soon deteriorates, so that no very satisfactory results were obtained.

METHODS EMPLOYED AT THE INSULAR EXPERIMENT STATION.

Crossing has been practiced at the Insular Experiment Station of Porto Rico for four years. The method here described was found to be more suitable, for the reason that with its use a fairly large number of seedlings can be produced. The work has not yet progressed far enough to report results of the crossing, in respect to the quality of varieties produced. It has been possible, however, to study to some extent the populations of seedlings originating from different parentages, as to inheritance of characters in first-generation seedlings.

Bags made of cheese-cloth are held extended by heavy wire rings sewed into them. The bags when completed are 48 inches long and 18 inches in diameter. The rings are placed one at the top and the other 16 inches from the bottom, so that a skirt of 16 inches is left to be drawn in and tied around the stems of the panicles.

The bags are supported over the panicles by means of bamboo poles set in the ground. The poles have a crossbar at the top which is fastened to them by being wedged into notches cut into the second internode from the top, and the bags are tied to this crossbar. The poles are set on the windward side of the stools just before the

[1] Figures in parentheses refer to "Literature cited."

panicles "shoot;" when this occurs, a bag is immediately suspended over each panicle and tied around its stem, so that it is protected from all undesired pollen before any of the florets open.

The cane blossom is hermaphrodite, but it has been found that certain varieties are almost completely pollen-sterile, or at least self-sterile. This makes it possible to pollinate them with another variety, with the assurance that nearly all the seedlings will be offspring of two known varieties, a few usually also being produced as the result of the self-pollination of the mother parent.

The pollinating is done by placing panicles of the desired variety into a bag, in such a position that their pollen will be shed or carried by the wind to the florets, of the other variety as they open. One or two panicles are used at a time, and they are allowed to remain in the bag two or three days, being renewed as often as necessary while the florets are opening. It has been found of advantage to cut the panicles with stems 4 to 6 feet long, and to place their lower ends in a joint of bamboo filled with water, by which they can be kept fresh two or three days.

RESULTS ACCOMPLISHED.

Up to the present time, results can only be expressed in terms of the number of seedlings produced and the extent to which the characters of the varieties are combined. The method above described was first tried in 1915–1916. Ten crosses were attempted, of a single combination, and all but two produced seedlings, a majority of which, when mature, showed characteristics of both parents In all, about 1,600 seedlings were produced, one panicle alone giving over 1,000 seedlings. (2)

In the following winter 1916–1917, thirty crosses, comprising nine different combinations, were attempted, and nineteen of them, comprising six combinations, were successful. From one combination 1,309 seedlings were obtained, and in all 2,589 seedlings were produced. The work was all done by one man and a helper, including the making of the bags.

In 1917–1918 it was impossible to secure the services of a competent man to perform the crossing until late in the season, and the seed of all varieties was also much less viable than in the preceding year. Thirty crosses were attempted, comprising nine combinations. Fifteen of these were successful and 1,794 seedlings were produced, 157 of which were from one combination and 735 from another.

Judging from the small proportion of the seedlings out of the large

number propagated by the old method that are of sufficient value to become widely cultivated, it appears that a large number of first-generation seedlings is essential. Considered from the point of view of Mendelian inheritance, if many factors are involved, which is probably the case, the chance of getting a desired combination of characters is very remote when only a few seedlings are grown.

EFFECT OF THE CROSSING.

In 1915–1916 the variety used as a pollinator was a dark-colored cane, while the seed parent was medium light. This made it possible to trace the color of the male parent in the offspring. Some other characters could also be traced in the seedlings in the same way. In the following year this cross was again made, and the same general effects were observed, many of the same types being again recognized. (2)

In the year 1916–1917, some of the parent varieties of groups of seedlings showed fewer differences than was the case with the varieties combined the year before, consequently it was less easy to see the effect of the crossing in the seedlings. In all cases but one, however, some of the groups showed distinguishing characters of both parent varieties.

The disadvantage in this method, in not being able to eliminate all possibility of self-pollination, ought not to be overlooked. On account of the chance of some selfing, it has been the practice to estimate the value of a cross from the entire group of seedlings produced, always making allowance for probable self-pollination.

SELF-STERILITY.

At least two of the old standard varieties are nearly pollen-sterile here. We have never succeeded in producing more than five seedlings from single flats of several hundred seeds planted, while if these varieties are pollinated by any of several seedling varieties good germination follows. Lewton-Brain (5) in Barbados examined the florets of about fifty varieties and found that some bore pollen nearly all of which was large, well-shaped and full of dark granules, while with some the pollen was smaller, more or less irregular in form, and without granular matter. A third class of varieties had an intermediate amount of normal, well-developed pollen.

Wilbrink and Ledeboer (6) describe a method of testing the pollen with iodine, to determine its viability. If the pollen grain con-

tains starch it was believed to be normal. We have not, however, found this test to be absolutely reliable.

CONCLUSIONS.

From the work reviewed in the foregoing paper the following conclusions are possible:

1. Sugar cane can be cross-pollinated and protected from outside pollen, and by this process a considerable number of seedlings can be produced.

2. Characters of the parent varieties are combined in the seedling by this process.[1]

LITERATURE CITED.

(1) Bovell, J. B.—Report of sugar-cane experiments. In Rpt. Barbadoes Dept. Agric., pp. 16–16. 1914.

(2) Cowgill, H. B.—Studies in inheritance in sugar cane. In Jour. Dept. Agr. Porto Rico, vol. 2, No. 1, pp. 33–41. 1918.

(3) D'Albuquerque, J. P.—Note on the artificial cross-fertilization in the sugar cane. In West Indian Bulletin, vol. 1, no. 2, pp. 182–184. 1900.

(4) Kobus, J. D.—De zaadplanten de Krusing van Cheribonriet met de Inglisch indische Varietiet Chunnee. In Mededeelingen vat het Proefstation voor de Java-Suikerindustrie, III, Nos. 1, 12, 21, 33.

(5) Lewton-Brain, L.—Hybridization of sugar cane. In West Indian Bulletin, vol. 4, no. 1, pp. 63–72. 1903.

(6) Wilbrink and Ledeboer, F.—De geslachaelijke voortplanting bij het Suikeriet. In Mededeelingen van het Proofstation voor de Java-Suikerindustrie, no. 6. 1911.

[1] It should be expected that the desirable combinations could be perpetuated in hybrid condition because of the asexual method of propagation, a rather unusual advantage among our field-crop plants.—(Editorial note by L. H. Smith.)

A PINEAPPLE FERTILIZER EXPERIMENT.

By P. González,[1] Horticulturist.

Full credit should be given our former plant breeder, Mr. H. B. Cowgill, for the fertilizer trial about to be reported on. The first crop was beginning to be harvested when Mr. Cowgill resigned. After his departure, the task of completing the harvest has devolved upon us and the making of a preliminary report based on the notes so obtained and on such data as were found available in the files of the Division of Agronomy and Horticulture.

The field selected for this experiment occupies an area of 0.67 acre and is situated on the slope of a hill facing northeast, and about 8 meters higher than the surrounding valley land. The approximate altitude of this level land being 80 feet above the level of the sea, the altitude of the field above that level can be taken to be about 106 feet. The angle of inclination of the slope is about 13.76 and the grade 22 per cent per meter.

SOIL.

Conditions of drainage, although not uniform, are fairly good. The soil is a stiff clay derived from the decomposition of the layer of shale upon which it rests. At the northwestern corner of the field the shale fragments can be seen at the surface mixed with the top soil. Analyses of this soil will be available for report of the 1919 crop. For the present an analysis[1] is given below of the soil and subsoil of a hill close to it, and of the same formation and physical characteristics.

	Sample No. 24 (*Soil*)	Sample No. 25 (*Subsoil*)
Insoluble residue	55.89	53.30
Volatile matter	14.48	11.60
Fe_2O_3	11.40	12.88
Al_2O_3	17.40	21.24
CaO	0.17	0.17
MgO	0.56	0.65
K_2O	0.22	0.22
P_2O_5	0.10	0.07
Total nitrogen	0.30	0.14
H_2O (air dry)	5.76	5.70

[1] Thanks are due the Director for his assistance in preparing the manuscript.
[1] These analyses were found on file in the records of the Division of Chemistry of the Insular Experiment Station, Río Piedras, P. R.

PLAN OF EXPERIMENTAL PLOT.

The plan of the experiment is clearly shown in Fig. 2. The field was equally subdivided (see Fig. 2) into (1) an upper lot to be fertilized with a complete fertilizer prepared from dried blood, bone meal and sulphate of potash, and (2) a lower lot to be fertilized with a complete fertilizer prepared from ammonium sulphate, acid phosphate and sulphate of potash. Of the first 36 plots, those which received the same treatment were:

Plots 1, 7, 13, 19, 25, 31—which were not fertilized.

Plots 2, 8, 14, 20, 26, 32—which received a full dose of each ingredient.

Plots 3, 9, 15, 21, 27, 33—whose dose of potash was reduced by two thirds, as compared with Plots 2, etc.

Plots 4, 10, 16, 22, 28, 34—which were not fertilized.

Plots 5, 11, 17, 23, 29, 35—Whose dose of phosphate acid was reduced by two thirds, as compared with Plot 2, etc.

Plots 6, 12, 18, 24, 30, 36—whose dose of ammonium was reduced by two thirds, as compared with Plots 2, etc.

ADDITIONAL PLOTS 37–41.

The phosphoric acid used in all the plots planned heretofore was to be derived from acid phosphate. It must have seemed desirable to try the effect of the same application of phosphoric acid derived from double super-phosphate. The latter would not carry any calcium sulphate along with it, as in the case of the acid phosphate. Accordingly, the field was further planned to include another plot, plot No. 39, identical with Nos. 2, 8, 14, 20, 26 and 32, except for the use of double super-phosphate instead of acid phosphate. Plot 39 duplicated 2, 8, 14, 20, 26 and 32 except that in the lower half dried blood was used instead of ammonium sulphate. The plan of the upper half of plots 2, 8, 14, 20, 26 and 31 was again repeated in an additional plot, plot 40. The latter differed from them, however, in that it was made 120 feet long, so that it occupied the upper as well as the lower portion of the field. The principal function of this plot 40 was a comparison of the relative efficiency of applying the fertilizer directly to the soil or in the axils of the leaves. It would also act as a check on the application of organic nitrogen and phosphorous on the upper portion of the slope by having an identical plot extending also into the lower slope. Finally the broader check plot was provided in plot No. 41.[1]

[1] NOTE.—Although plot 41 is supposed to be a check plot, a note has been found in the records of the Division of Agronomy to the effect that the plot had been fertilized with dried blood.

Plot	LOWER PLOT—INORGANIC NITROGEN AND PHOSPHORUS 60 ft. 120 plats.			UPPER PLOTS—ORGANIC NITROGEN AND PHOSPHORUS 60 ft. 120 plants.	
1	UNFERTILIZED			UNFERTILIZED	
2	36¾ lbs............	12 lbs. Ammonium sulphate 18¾ lbs. Acid sulphate 6 lbs. Potassium sulphate	(Full dose)	47.9 lbs.	13.9 lbs. Dried blood 28.05 lbs. Bone meal 6 lbs. Potassium sulphate
3	32 lbs............	12 lbs. Ammonium sulphate 18¾ lbs. Acid phosphate 2 lbs. Potassium sulphate	(⅔ less K_2O)	43.9 lbs	13.9 lbs. Dried blood 28.05 lbs Bone meal 2.00 lbs. Potassium sulphate
4	UNFERTILIZED			UNFERTILIZED	
5	24¼ lbs............	12 lbs. Ammonium sulphate 6¼ lbs. Acid phosphate 6 lbs. Potassium sulphate	(⅔ less P_2O_5)	29¼ lbs...........	13.9 lbs. Dried blood 9.35 lbs. Bone meal 6 lbs. Potassium sulphate
6	28¾ lbs............	4 lbs. Ammonium sulphate 18¾ lbs Acid phosphate 6 lbs. Potassium phosphate	(⅔ less N)	38.6 lbs..............................	4.64 lbs. Dried blood 28.05 lbs Bone meal 6 lbs. Potassium sulphate
	(These first 6 plots were repeated 5 additional times so that there resulted 36 plots. every consecutive 6 plots of which were treated identically with the first 6 shown in this plant.)				
37	UNFERTILIZED			UNFERTILIZED	
38	25½ lbs............	12 lbs. Ammonium sulphate 7½ lbs Double superphosphate 6 lbs. Potassium sulphate	(Full dose)	27.4 lbs..............................	13.9 lbs. Dried blood 7½ lbs. Double superphosphate 6 lbs. Potassium sulphate
39	38.6 lbs............	13.9 lbs. Dried blood 18¾ lbs. Acid phosphate 6 lbs. Potassium sulphate	(Full dose)	49.9 lbs..............................	13.9 lbs. Dried blood 28.05 lbs. Bone meal 6 lbs. Potassium sulphate
40	47.9 lbs............	13.9 lbs. Dried blood 28.05 lbs. bone meal 6 lbs. Potassium sulphate	(Full dose)	47.9 lbs..............................	13.9 lbs. Dried blood 28.05 lbs. Bone meal 6 lbs. Potassium sulphate
41	UNFERTILIZED			UNFERTILIZED	
	60 feet			60 feet	

FIG. 2.—Plan of the Experimental Plots.

PLANTING.

The slips were set in the field in 1917, in two-row beds, 5 feet apart. The plants were set 1 foot apart in the rows. Each plot contained 240 plants in two rows of 120 plants each. This allowed 60 plants to the row for the upper half of the plot and 60 for the lower half.

APPLICATION OF FERTILIZER.

Application of fertilizers were made June 8, 1917; September 1, 1917; and January 22–24, 1918. In the case of plot 40, the fertilizer was applied to the soil in the lower half, and in the axils of the leaves in the upper half.

EFFECT OF TREATMENT.

Notes taken by Mr. H. B. Cowgill, April 3, 1918, show that on this date—

"Chemical Plots No. 2 and its duplicates, having received a full dose of fertilizer, appear, in general, better than the rest.

"Chemical Plots No. 5 and its duplicates, having received two-thirds less phosphoric acid, appear almost as good as Plots No. 2 and duplicates.

"Chemical Plots No. 3, having received two-thirds less potash, appears third best.

"Chemical Plots No. 6 and duplicates, having received two-thirds less nitrogan, appear fourth best. They are poor, but are better than the unfertilized Plots Nos. 1 and 4.

"There appears to have been, at this stage of development, no uniform difference between the plots in the mineral fertilizer series and the corresponding plots in the organic fertilizer series.

"Nos. 38 and 39, in the lower series, appeared about equal.

"No. 39, upper series, appears to be the best of all.

"No. 40, upper and lower series, poor and both about the same."

THE HARVEST.

The picking and grading of pineapples extended from June 19 to October 8. A good number of pineapples were produced after October 8. These have not been included in this report. The number of fruits harvested per plot and their individual sizes will be found in the adjoining tables.

Pineapple Fertilizer Experiment.

TABLE I.

	Lower Series		*Upper Series*	
Plots	Average size of fruits	Total number fruits harvested	Average size of fruits	Total number fruits harvested
1	40.85	20	43.02	47
2	32.19	51	32.78	57
3	33.66	54	35.48	58
4	38.07	52	37.75	82
5	32.22	45	29.66	53
6	34.87	87	37.81	58
7	42.48	89	38.89	58
8	33.55	59	34.87	64
9	28 82	48	34 94	76
10	44 21	46	37.85	71
11	31.52	75	31.70	81
12	30.74	57	36.16	71
13	45.05	58	40 42	56
14	30.15	78	42.10	56
15	31.52	55	35.66	84
16	36.30	60	47.29	51
17	36.32	74	39.52	75
18	34.22	54	38.46	56
19	39.94	88	41.80	81
20	38 05	61	40.40	60
21	35.85	40	39.29	51
22	42 ?5	14	41.18	37
23	30.36	51	32.45	54
24	38.19	21	37 58	47
25	44.40	10	27.02	29
26	31.57	40	36.00	72
27	32 57	28	38 82	34
28	47.40	10	43.20	10
29	30.87	55	33 60	50
30	39.37	16	39 20	15
31	44.50	12	44.30	13
32	46 12	88	37.93	29
33	37.44	34	38.59	21
34	45 47	19	43.38	18
35	34.00	49	35 45	44
36	39.39	33	40 71	14
37	46.68	23	42.00	14
38	33.82	69	31.78	37
39	29 39	49	36.80	45
40	37.30	46	37 50	16
41	46.21	37	46.04	46

In order to bring out more comprehensively the effect of each treatment, the following Table II has been prepared by condensing the data given in Table I:

Pineapple Fertilizer Experiment.

TABLE II.

UPPER SERIES.

Plots	Treatment	Total No. of fruits harvested	Average No. of fruits harvested	Average size of fruits
(1) 1, 7, 13, 19, 25, 31	Not fertilized	234	39.0	39.24
(2) 2, 8, 14, 20, 26, 32	Full dose	338	56.3	37.33
(3) 3, 9, 15, 21, 27, 33	⅔ less P_2O_5	324	54.0	37.13
(4) 4, 10, 16, 22, 28, 34	Not fertilized	264	44.0	41.77
(5) 5, 11, 17, 23, 29, 35	⅔ less P_2O_5	357	59.5	33.73
(6) 6, 12, 18, 24, 30, 36	⅔ less N	261	43.5	38.22
(Organic) Series average		296.33	49.38	37.9

LOWER SERIES.

Plots	Treatment	Total No. of fruits harvested	Average No. of fruits harvested	Average size of fruits
(1) 1, 7, 13, 19, 25, 31	Not fertilized	172	28.6	42.37
(2) 2, 8, 14, 20, 26, 32	Full dose	325	54.5	34 43
(3) 3, 9, 15, 21, 27, 33	⅔ less K_2O	259	43.16	33.31
(4) 4, 10, 16, 22, 28, 34	Not fertilized	201	33.5	42.38
(5) 5, 11, 17, 23, 29, 35	⅔ less P_2O_5	349	58.16	32.54
(6) 6, 12, 18, 24, 30, 36	⅔ less N	218	36.33	36.04
(Inorganic) Series average		254.33	42.37	36.9

The results obtained would seem to show that nitrogen is the element which most influences production; then, potash. The larger applications of acid phosphate may be interpreted as having been prejudicial. The data are brought together below:

NITROGEN.

	Total No. of fruits (Average)	Average size (No. fruits per box)
Upper series		
Full dose of N	338	37.33
⅔ less of N	261	38.22
Difference	77	—0.89
Lower Series		
Full dose of N	327	34.43
⅔ less of N	218	36.04
Difference	109	—1.61

POTASH.

Upper series		
Full dose of K_2O	338	37.33
⅔ less of K_2O	324	37.13
Difference	14	+0.20
Lower series		
Full dose of K_2O	327	31.43
⅔ less of K_2O	259	33.31
Difference	82	+1.12

PHOSPHORIC ACID.

Upper series		
Full dose of P_2O_5	338	37.33
⅔ less of P_2O_5	357	33.73
Difference	—19	+3.60
Lower series		
Full dose of P_2O_5	327	34.43
⅔ less of P_2O_5	349	32.54
Difference	—22	+1.89

CONCLUSIONS.

It would be premature to draw general conclusions based on the results obtained with one crop. However, the benefit derived from the application of fertilizers is illustrated strikingly by the appearance of the unfertilized plots in the field as compared with the fertilized ones as well as by the number and size of the fruits harvested. (See Fig. 3.) The average total number of fruits produced by the upper plots which received fertilizer in any way was 325 of an average size of 35.37 per box as compared with 249 of an average size of 40.5 per box in the unfertilized ones. The corresponding figures for the lower plots were 288.25 of an average size of 34.13 per box for the fertilized as compared with 186.5 of an average size of 42.63 per box for the unfertilized. In other words, the treatment increased the number of fruits by over 30 per cent and the size of fruits by over 12 per cent for the upper (organic) plots and over 54 per cent and 19 per cent, respectively, for the lower (inorganic) plots.

The results obtained might also indicate that the beneficial effect of the organic fertilizer has been greater than that of the inorganic fertilizer. However, after leaving out the checks, the differences established below do not warrant that conclusion, especially in view of the fact that the difference in number and size of the fruits in the check plots of the upper as compared with the lower suggests a difference in soil conditions.

	Total No. of fruits	
Average of plots fertilized with organic N & P_2O_5........	320.	36 60
Average of plots fertilized with inorganic N & P_2O_5.....	288.75	34.08
Difference...	31.75	+2.52

In Table V, given below, the results obtained in plots 39–40[1] are compared with the average figures from plots 2, 8, 14, 20, 26 and 32 and check plot 37.

[1] Plot 41 is omitted, since, as remarked above, it was fertilized presumably by mistake.

Pineapple Fertilizer Experiment.

TABLE V.

UPPER SERIES.

Plots	Treatment	Average No. of fruits	Average size of fruits
2, 8, 14, 20, 26, 32	Full dose (bone meal)	56.33	39.24
37	Not fertilized	37	31.78
38	Full dose (doble superphosphate)	45	36.80
39	Full dose	16	37.50
40	Full dose (applied to plant)	14	42.00

LOWER SERIES.

Plots	Treatment	Average No. of fruits	Average size of fruits
2, 8, 14, 20, 26, 32	Full dose (acid phosphate)	56.3	36.24
37	Not fertilized	69	33.82
38	Full dose (double superphosphate)	49	29.39
39	Full dose (dried blood)	46	37.30
40	Full dose (applied to soil)	28	46.68

Since the figures given in Table III have been obtained from single plots, comments on them are withheld until further data are available.

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VARIETIES OF SUGAR CANE IN PORTO RICO.

By F. S. EARLE, Agronomist, Insular Experiment Station.

The question of sugar-cane varieties has attracted much attention for many years, and there can be no doubt of its supreme importance to the cane planter. The number of existing varieties is now very great and it is being added to each year by enthusiastic plant breeders in all parts of the sugar world. There is a voluminous literature on the subject. The planter therefore has no lack of material from which to choose but in most regions there is a serious lack of knowledge as to the adaptability of these multitudinous kinds to the requirements of local needs and conditions. A few investigators, particularly Bovell in Barbados and Harrison in Demerara, have done a noteworthy service in the laborious and careful testing of the many kinds they have produced and the recording of the results obtained with each under varying local soil and cultural conditions. This work, now continued over a long series of years, has been of inestimable benefit to the communities concerned, as it has served to very greatly increase the average yields of sugar. Unfortunately, we cannot assume that the results obtained by these careful investigators will be universally applicable. The same painstaking testing needs to be repeated, not only in each of the cane-growing countries, but in each of the principal soil and climatic districts within each country. For each variety we need to know whether it is best adapted to low, wet soils or to high and dry ones; to sandy loams or to heavy clays; whether it matures early, and is thus suitable for late spring planting, or whether it requires a long season for maturity and consequently should only be planted in the fall as "*gran cultura;*" above all we need to know its ratooning powers and how many cuttings may be expected from a given planting under any of the above conditions. Since cane is grown only for

the sugar that can be extracted from it the percentage of sucrose, the purity and the total recoverable sugar produced per acre are factors of vital importance. Unfortunately, great vigor and high tonnage are not always associated with high sucrose content and purity. In fact some investigators claim that they are antogonistic, that unusually high sucrose content is an abnormality, and that it is always accompanied by somewhat lessened vigor. Be this as it may, the fact remains that the record for highest sugar production per acre is often held by a variety with a comparatively low sucrose content. The fact that the planting of low-grade canes is sometimes most profitable is abundantly shown by the fact that in Demerara the acreage of D–625 far exceeds that of any other kind while in the Hawaiian Islands for many years the bulk of the sugar has been produced from the Yellow Caledonia, both varieties that are notoriously low in sucrose. It is by no means a simple matter to decide what policy is best to follow in this respect. It will depend on many factors. To get a given number of tons of sugar from a low grade cane requires the cutting, handling and grinding of a considerably increased tonnage—it requires more labor. The higher per cent of fiber in these canes will give more fuel for the boilers, but, on the contrary, it needs more steam to concentrate these diluted juices and more power to grind the harder fibrous cane. The policy to follow must then largely depend on the two factors of labor supply and mill capacity. Where labor is abundant and mill capacity rather in excess of cane supply, as is usually the case in Porto Rico, the policy should be to plant those kinds that will give the greatest yield of sugar per acre even if this involves the handling and milling of some extra tons of cane. In those countries on the contrary where cane can be easily grown in excess of milling capacity, and where labor is scarce and high, the policy had better be to plant those canes which give the greatest yield of sugar per ton of cane handled. The above discussion will apply in its entirety only where mills grow their own cane. Where they buy it from *colonos* on a tonnage basis, as is most usually the case, a conflict at once arises. It is the interest of the *colono* to produce the most tons possible per acre, while the mill owner wishes to insist on the planting of only those kinds yielding the richest juice. This conflict can only be adjusted by changing cane contracts so as to pay on the basis of the actual sugar content of the cane delivered. In any event we are greatly in need of much more accurate knowledge as to the probable behavior of the confusing number of varieties with

which we are confronted under each of the many and varied cultural conditions. This knowledge can only be obtained from the records of careful trials extending over a term of years. We need to know not only how each variety yields under ordinary plantation treatment on each of the principal soil areas but how it responds to special treatment—better cultivation, more fertilizer and irrigation. Another most important point to determine is that of comparative resistance or susceptibility to the various diseases and insect pests that attack cane. The failure of kinds commonly cultivated when attacked by some of these many enemies, and the search for kinds having greater resistance, has been the leading cause for the production of this multitude of new varieties.

A discussion of cane varieties will naturally fall under two quite distinct headings, the one dealing with their cultural values and characteristics, and the other with their description and classification—the one treating them from the agricultural viewpoint, the other from the botanical or taxonomic. The literature of the subject will be found much more useful in the first part of the discussion than in the second. It is really remarkable how few descriptions of cane varieties have been published that would by any possibility enable one to identify the variety. This is perhaps natural enough since the students of cane varieties have as a rule been agriculturists and not botanists. One of the principal objects of this paper is to show that cane varieties may be described, classified and keyed out and determined by the ordinary methods of descriptive botany or taxonomy. They seem to present no greater difficulties than do any numerous groups of closely related natural species.

CULTURAL VALUE AND CHARACTERISTICS OF CANE VARIETIES IN PORTO RICO.

The cane originally planted in Porto Rico was known as the Creole. It was a soft cane of only moderate tonnage and sugar value. About the beginning of the nineteenth century it was quite completely surplanted by the cane variously known as Otaheite, Bourbon or Caña Blanca. This gave much better yields and it came to be almost universally planted not only in Porto Rico but in the other islands of the West Indies. In fact the sugar industry of this part of the world was for many years almost exclusively based on this variety. In 1872 a disease appeared in western Porto Rico which caused heavy losses and for some years threatened the ruin of the industry in this part of the Island. A government commission was

appointed to study the disease composed of Drs. Grand-Court, Agustín Stahl and José Julián Acosta. They issued a full report in 1878 in which while admitting that they had been unable to determine the cause of the disease they strongly urged the abandonment of the Caña Blanca and the planting of the Morada, the Rayada and the Crystalina, which they found to be resistent to the malady. The cause of this epidemic is still uncertain. It was probably a combination of root disease, *Colletotrichum* red rot, and white grub, to all of which troubles the Caña Blanca is particularly susceptible. At any rate, it caused the abandonment of this variety in all the northern and western districts and its substitution by other more resistant kinds. Since the American occupation many other kinds have been imported, especially the Demerara and Barbados seedlings, and both of the Experiment Stations and the Centrals Guánica and Fajardo have actively engaged in the breeding of new seedlings. It has been impossible to accurately determine the number of varieties now existing on the Island but there is reason to believe that it is considerably in excess of 500. The proper field study of so great a mass of material is a serious undertaking. So far it has not been done in an adequate, systematic way. We know that there are many very promising kinds but we have very little knowledge as to real capability and limitations. Besides the 44 kinds described in this paper various others have from time to time been planted on a plantation scale, the selection of the present list has been largely a matter of convenience. Guánica and Fajardo are also planting considerable areas of a number of their own seedlings that have not been disseminated, and Central Mercedita has imported and is growing a number of the newer Barbados kinds that are not mentioned here. Unfortunately, except on a few of the more carefully managed places no attempt seems to have been made to keep varieties planted separately. The new varieties sent out by the Experiment Stations are found indiscriminately mixed with the other kinds. It is rare to see a car of cane that does not show a perplexing mixture of colors and kinds. This of course is most unfortunate from every point of view. It is worse than useless to send out new varieties to planters who will not at least plant them separately.

OTAHEITE, BOURBON OR CAÑA BLANCA.

As stated above, for seventy-five years this was practically the only cane planted in Porto Rico. It is well adapted to rich, moist but well-drained, new lands. Under these conditions it grows with

great vigor. It is a good milling cane and gives juices above the average in sugar content and purity. It matures early and so is suitable for late spring plantings. It is, however, highly susceptible to root disease and to injury from the white-grub attacks. For these reasons it ratoons very badly on old worn soils. It is also very susceptible to *Collètotrichum* red rot and unless harvested as soon as mature it is liable to serious losses on this account. These inherent weaknesses caused its abandonment in northern and western Porto Rico during the epidemic of 1872–80. It is still cultivated to some extent in the southern and eastern districts, usually under irrigation. It ratoons so badly that it is now mostly confined to those plantations that practice plowing up and planting each year. From first place it has now fallen to about fifth in total acreage. It can only be planted under the most favorable conditions, and even then its planting can not be advised since there are other equally good kinds that can be planted with less risk. It has also been badly injured by the mosaic disease. Much has been written about the running out or deterioration of this cane. Facts in support of this theory, however, seem lacking. Planted on new timber lands, the condition for which it is adapted, it still grows with its old-time vigor. In other words, it is the deterioration of the land under continued cultivation, and not the running out of the variety, that has caused its abandonment throughout the West Indies. Its root system is not adapted to the bad cultural conditions found in worn, compacted and impoverished soils.

Rayada.

This seems to be the same as the Ribbon Cane of Louisiana and the Rayada of Mexico and South America. First generally planted as the result of the epidemic of 1872–80, it is now the prevailing kind in all the northern and western districts and is also commonly found in the south and east. At present it undoubtedly holds first place in total acreage. The tonnage yield is perhaps never quite so great as with Otaheite, when at its best, but the average yields are better since it is a hardy cane adapted to a wide range of soils and conditions. In richness of juice and purity it stands high, often going above 15 per cent sucrose and 90 per cent in purity under heavy mill extraction. One of its greatest advantages is its power of continued ratooning. Fields are in existence on the north coast of Porto Rico that have been in continuous production for over twenty years. Eight and ten-year ratoons are not uncommon on

good lands and with reasonably good care. The Rayada is a medium-season cane not reaching its best condition under 14 or 15 months, but it can be cut at 12 months. Being highly resistant to the red rot fungus, *Colletotrichum*, it can remain long in the field after maturity without deterioration. It suffers considerably from the moth-borer, being about the average in this respect. It is attacked by root disease and white grubs, but as shown by its ratooning power it suffers less than many other kinds. It is freely attacked by the mosaic disease, but shows a considerable degree of resistance to its effects. The stalks of diseased plants do not develope serious cankers until in advanced stages of the disease. With good cultivation and extra nitrogenous fertilizers heavily diseased fields may be made to yield three-fourths of a normal crop.

This cane has often been surpassed both in tonnage and total sugar yield per acre by some of the newer kinds, but it is by no means proven that any of these could profitably replace it under the many conditions where it succeeds. Until this proof is fully convincing it should continue to be planted in all those districts where it is now the favorite.

CRYSTALINA.

This cane is now second in acreage in Porto Rico, being most abundant in the southern part of the Island. It is the kind commonly grown in Cuba, where in the eastern provinces it is sometimes known as Ceniza. Under the name of White Transparent it was long the standard kind in Barbados and other of the West Indies, though there it is now largely superceded by some of the newer seedlings. It has also been known as Mont Blanc, Caledonian Queen, and by many other names. According to Noel Deerr it is the White Cheribon and originated as a bud sport from the Striped Cheribon, our Rayada. It is known as Rose Bamboo in Hawaii, but is not the cane known by that name here, which is probably the Salangore. Whatever its origin or synonamy, it is culturally so closely like Rayada that all the remarks made under that heading may be applied here. It seems to be largely chance that one is planted more commonly in the south and the other in the north side of the Island. Each planter usually has a strong preference for either one or the other but no two agree as to their cultural differences. Both are good canes and should not be hastily discarded. For comparison with the other varieties the record of yields as given by Cowgill and McConnie are given here:

COWGILL, Insular Experiment Station. Circular 8: 11, 1917. Average of 2 lots of Crystalina and 1 of White Transparent plant cane; 41.97 tons, 1st ratoon, 21.31 tons; 2nd ratoon, 9.91 tons; sucrose, 16.38 per cent; purity, 93.1 per cent.

MCCONNIE, Revista de Agric., 1: 17, 1918. Under name of White Transparent average of 2 crops, 26.73 tons; sucrose, 12.2; purity, 87.8; tons sugar, 3.31; 10th in total sugar out of 25 kinds.

It may be added that in the irrigated fields of Central Aguirre, Crystalina has at various times made yields of over 80 tons per acre, which is decidedly more than has been recorded for any other variety. This shows how well this old standard kind responds to good culture. It is unfortunate that tests of other kinds were not made under the same conditions.

CAVANGERIE.

This cane, known as Caña Colorada and French Cane, is another kind that came into general cultivation as a result of the epidemic of 1872. It stands drought exceedingly well and will make a fair tonnage on lands so hard and dry that most other kinds fail. It is also quite resistant to root disease and so ratoons well. For these reasons it has been quite widely planted, especially by small *colonos*, notwithstanding the fact that it is notoriously low in sucrose and high in fiber, and that the mills usually discriminate against it. No statistics are available, but it seems probable that before the outbreak of the mosaic disease the total acreage of this cane equaled or exceeded that of the Crystalina. While markedly hardy in other respects it is exceedingly susceptible to this disease, and when attacked it suffers more seriously than any other kind in general cultivation. This seems to be the chief reason why this disease has caused the abandonment of cane cultivation on so many farms in the Isabela district, and at many other points in the hill lands along the north coast, and in the center of the Island. These are the districts where this red cane was so widely planted. On contracting the mosaic disease growth is soon checked, and the canes become so badly cankered as to be dry and worthless and the field has to be abandoned. It is clearly unadvisable to plant this cane in districts where this disease is prevalent. Whether it should be planted at all, even in districts free from mosaic, is perhaps an open question. The mills certainly all oppose it, since it is a hard cane to grind and gives an unsatisfactory yield of sugar per ton of cane. Comparative statistics of yields are scanty, but as reported in Insular Station Circular No. 8, it stood third in total tonnage for three crops being only sur-

passed by the equally poor D-116 and D-625 and it was fifth in total sugar per acre out of a list of twenty-five kinds. This record is good enough to at least call for further study in a country like Porto Rico where mill capacity is in excess of cane supply.

YELLOW CALEDONIA.

This cane came to Porto Rico from Hawaii some years ago. Its planting has gradually increased until it now probably holds fourth place in total acreage and its planting is being extended more rapidly than that of any other kind. Its popularity is due to its resistance of root disease and its ability to grow and give good yields on worn, compact, wet lands where Rayada and other better kinds no longer yield nor ratoon satisfactorily. It seems to give down rather quickly when attacked by the white grub and it is injured decidedly more by the mosaic disease than the Rayada. If its further planting is not checked by this last factor, it seems destined to replace the Rayada and Cristalina, at least on the heavy compact wet lands of the north coast. Wherever it is found on such lands it is growing so much better than the Rayada as to immediately attract attention. Its planting has been discouraged by the mills since it is comparatively low in sucrose and high in fiber, but this will not prevent its continued and increased planting unless it is checked by its susceptibility to the mosaic disease. It requires plenty of moisture and should not be planted on high dry soils. Published records of performance are few and by no means do justice to the real vigor and productiveness of this cane as seen in hundreds of fields in all parts of the Island.

COWGILL, Annual Report, 23, 1917. Was fifth in total tonnage as plant cane and 1st ratoons out of a list of 9 kinds. Plant cane, 28.75 tons; 1st ratoons, 12.25. Average sucrose, 15.5 per cent; purity, 86.51 per cent.

COWGILL, Insular Experiment Station Circular 8: 11, 1917. Weight of plant cane not given. As first ratoon only took 8th place out of a list of 25 kinds. 1st ratoons, 29.35 tons; 2nd ratoon, 17.45 tons; sucrose, 14.85 per cent; purity, 85.9 per cent.

MCCONNIE, Revista de Agric., 1: 17, 1918. 8th in total sugar out of 25 kinds. Average of 3 crops, 32.31 tons; sucrose, 10.8 per cent; purity, 81.7 per cent; tons of sugar, 3.41.

THE DEMERARA SEEDLINGS.

A number of the seedlings grown in Demerara by Mr. Harrison have been imported at various times and the following five have been more or less extended on a plantation scale. No statistics as to acre-

age are available. These kinds are distinguished by the initial D. D-74 and D-95, the well-known kinds so much planted in Louisiana, were also grown at one time, but seem to have been dropped. This was doubtless a mistake, so far at least as D-74 is concerned, for this cane matures so early that it should be very useful to plant in the late spring and also to have a few fields of earlier planting on which to begin the grinding. In early December it often shows fully 3 per cent more sucrose than Rayada or Crystalina at this same date. At ten months it will be sweeter and better to grind than Crystalina at twelve months. This point in the hands of a skilled planter would make it very valuable although it would not be suitable for the main planting under Porto Rican conditions. It yields and ratoons about as well as Rayada or Crystalina.

D-109.

This cane has been more or less planted for a number of years. It is a good general-purpose cane, doing well on a veriety of soils. It seems particularly well adapted to the red shale clay hills. It ratoons well, showing considerable resistance to root disease. In all these respects as well as in sucrose content and purity it is just about equal to Rayada and Crystalina. It is, however, more susceptible to injury from mosaic disease, so there seems to be no particular reason for extending its planting.

It never took very high rank in Demerara, being twelfth in total sugar production out of a list of 72 kinds. Jour. British Guiana 11:11, 1918. It does not figure in the Barbados reports, but has been rather a favorite at some of the smaller islands, particularly at St. Kitts and Nevis, where it has held first place in tonnage. Its record here is as follows:

COWGILL, Insular Experiment Station Cir. 8: 11, 1917. Plant cane, 36 57 tons; ratoons, 24.55 tons; 2nd ratoons, 17.60 tons; sucrose, 14.98 per cent, purity, 87 per cent.

MCCONNIE, Revista de Agric., 1: 16, 1918. 19th in total sugar out of 25 kinds. Average yield 3 years, 23.21 tons; sucrose, 11.4 per cent; purity, 85.3 per cent; tons of sugar, 2.97.

D-117.

This kind seems to have attracted very little attention in the other islands of the West Indies, but here it is one of the most valuable we have. It grows well on a variety of soils, but seems to be particularly adapted to planting as long crop or "*gran cultura*" in the irrigated lands of the south coast, where it is quite largely

planted, especially on the Guánica estates. It ratoons well thus showing its resistance to root disease. Fortunately, it is, if anything, more resistant to mosaic than the Rayada. It is a rather late maturing cane, but when well ripened the sucrose and purity are good. Under most conditions it will outyield Rayada and Crystalina. Its much wider planting can be safely encouraged. Its published record follows:

MAY, Federal Station, Bull. 9: 10, 1919. At Guánica in 1908, tons, 56.45; sucrose, 14.4 per cent; purity, 83.2 per cent. At Monserrate in 1908, tons, 64.60; sucrose, 15.0 per cent; purity, 85.0 per cent.

COWGILL, Annual Report, 3: 9, 1915, on hill, hand plant, 19.9 tons. 1st ratoons, 34 tons; 2nd ratoons, 13.01 tons; sucrose, 14.10 per cent; purity, 81.8 per cent.

Annual Report, 23, 1917. Plant 30 tons; 1st ratoon, 20.90 tons; sucrose, 13.6 per cent; purity, 83.4 per cent and 89.48 per cent.

Ibed., p. 25. Plant, 20.55 tons; sucrose, 19.94 per cent; purity, 92.40 per cent.

Annual Report, 5: 26, 1917. Cut at 11 months; 1st in tonnage in a list of 9. Plant cane, 30 tons; sucrose, 13.6 per cent; purity, 83.4 per cent.

Insular Station, Circ. 7: 11, 1917. Stands 2nd in tonnage out of a list of 25. Plant, 57.53 tons; 1st ratoon, 25.76 tons; 2nd ratoon, 16.30 tons; sucrose, 15.92; purity, 90.0 per cent.

MCCONNIE, Revista de Agric., 1: 15, 1918. 13th in total sugar out of 25 kinds. Average of 3 years, 29 tons; sucrose, 11 per cent; purity, 82.9 per cent; total sugar, 3.17 tons.

D-433.

This is a favorite cane at Fajardo on the east coast where, it is being quite largely planted. It seems particularly well adapted to low, wet lands, where it makes a very heavy tonnage. It also grows very well in the red clay hills. It seems to be resistant to root disease. It has been but little noticed in the literature, but it is reported in Jour. Brit. Guiana, 11: 11, 1918, as highest in total sugar yield out of a list of 72 kinds. Here its only published record is the following:

MCCONNIE, Revista de Agric., 1: 15, 1918. 9th in total sugar out of 25 kinds. Average tonnage for 3 years, 31.18; sucrose, 11.5 per cent; purity, 83.2 per cent; total sugar, 3.53 tons.

D-448.

This cane is also thought highly of at Fajardo where it is considerably planted, and where it is giving good yields. It is seldom mentioned in the literature and its one published record here does not do it justice.

McCONNIE, Revista de Agric., 1: 16, 1918. 24th in total sugar out of 25 kinds. Average of 2 crops; 16.89 tons; sucrose, 11 per cent; purity, 83.3 per cent; total sugar, 1.[illegible] tons.

D–625.

This is another vigorous productive cane, but having low sucrose and purity. It has been considerably planted, especially on the east coast, but it is mostly found mixed in with other canes as the mills refuse to receive it if planted in pure cultures. A cane has also been planted in Porto Rico under the name of D–116. Some observers claim that it, as grown here, is identical with D–625, while others hold them to be distinct. The writer has not seen any cane under the name of D–116, so cannot attempt to decide the matter. At least they are similar in cultural characteristics. Whether or not it is ever desirable to plant low-grade canes of heavy tonnage has been discussed in another place. Notwithstanding its low sucrose content it has steadily gained ground in the country of its origin until it occupies (crop of 1916) half of the acreage of the colony. It is not always highest in tonnage and only stands fourth in total sugar per acre. Jour. Brit. Guiana 11: 155, 1918. In the smaller islands it often takes first place in tonnage. Its record here follows:

COWGILL, Insular Station Circ. 8: 11, 1917. Plant, 56.27; 1st ratoon, 44.46 tons; 2nd ratoon, 28.52 tons; sucrose, 10.65 per cent; purity, 71.1 per cent. D–116 here treated as district gave the following: Plant, 63.60; 1st ratoon, 60.70; 2nd ratoon, 28.52 tons; sucrose, 10.65 per cent; purity, 71.1 per cent. D–116 1st place in total tonnage and also as plant cane, out of a list of 25 kinds. D–615 was 2nd in total tonnage, but fell to 3rd place in tonnage as plant cane, being surpassed by D–117.

McCONNIE, Revista de Agric., 1: 17, 1918, as D–116. 2nd in total sugar out of 25 kinds. Average of 2 crops, 38.48 tons; sucrose, 10.3 per cent; purity, 78.7 per cent; total sugar, 3.99 tons.

THE BARBADOS SEEDLINGS.

Up to 1916 (Barbados Rept. 1916–17) a total of 73,469 seedlings had been grown in Barbados by Mr. John R. Bovell and his associates. Of this great number, 7,078 had been selected and replanted for further study. Of these, 3,222 were still in cultivation during that year and 738 were weighed and analyzed. This is one of the greatest tasks in plant breeding that has been accomplished anywhere in the world. It has been of incalculable value to the sugar industry of that island since the best of these new kinds are now almost exclusively planted and are giving sugar yields almost twice

as great as the Crystalina, which under the name of White Transparent was the kind formerly planted. Replying to questions as to the parentage of some of the varieties discussed in this paper in a letter dated January 28, 1919, Mr. Bovell writes interestingly as follows:

"I beg to enclose herewith a list of the canes you mention with a statement against each showing, where known, the parentage. When I first commenced to grow seedling sugar canes in Barbados, in addition to sowing seeds in boxes taken from sugar cane the names of which I know, I used also to go about the fields and where I found seeds germinating I would transplant the young plants into pots, and so in such instances I would be unable to record the parentages. With regard to the varieties of the sugar canes which you mention as being cultivated in Porto Rico now, I may mention that in Barbados we are practically only cultivating the B-6450, nearly all the others having been discarded. At the present time we have canes that are far superior to the B-6450 even, not only in tonnage and sucrose content, but also in resistance to various diseases. The seedling sugar canes Ba-6032 and BH-10(12) which are now being generally cultivated in the plantations are, I am glad to tell you, giving splendid results here. The BH-10(12) is not only a good germinator, but it is a cane that gives an exceptionally good tonnage and the sucrose content and quotient of purity are high. Last year at one factory that has an eight roller mill it took only seven tons to make a ton (2,240) of sugar."

Besides the 12 kinds discussed in this paper, all but one of which, it seems, are now discarded there, various others of the Barbados seedlings have been introduced and more or less planted. None of them, however, seems to have gained much foothold. Seed canes of the two kinds mentioned by Mr. Bovell have recently been imported by Central Guánica and it will be of great interest to watch their behavior here.

B-109.—Parentage Unknown.

This is a good vigorous cane of about the same cultural value as the Crystalina, often being a little better in tonnage, especially as ratoons, but not quite so high in sucrose and purity. Cowgill recommends it for the red shale hills. It is fairly resistant to root disease, as shown by its good ratooning powers, but its behavior in regard to the mosaic disease has not been determined. It is doubtful if it has any special advantage over other kinds, but it should not be discarded without further trial. It has never won a place in Barbados, but has been more or less planted in the smaller islands, where its record has usually been a medium one. In one three-year test it took second place in Antigua. Its published record here follows:

COWGILL, Insular Station Circ. 8: 11, 1917. Plant, 34.59 tons; 1st ratoon, 24.25; 2nd ratoon, 14.70; sucrose, 15.61 per cent; purity, 89.8, standing 12th in total tonnage out of 25 plots.

Annual Report, 25, 1917. Plant, 28.70 tons; sucrose, 18.20; purity, 88.80, taking 1st tonnage out of 6 kinds, Rayada in same test making 24.10 tons and B-3412, 26.25 tons.

MCCONNIE, Revista de Agric., 1: 16, 1918. 12th in total sugar out of 25 kinds. Average for 2 years, 23.37 tons; sucrose, 11.3 per cent; purity, 84.7 per cent; total sugar, 3.24 tons.

B-208—PARENTAGE UNKNOWN.

When all conditions are favorable this is a splendid cane. It was the first of the Barbados seedlings to attract wide attention. It has been carried all over the world and has probably been more widely planted than any of the others. Like the Otaheite, it requires a deep mellow, moist but well-drained soil. In such situations and with a regular water supply it gives good tonnage and juices among the highest known in sucrose and purity. It matures early, so it can be used for late spring planting. It is not suited to hard dry soils and is easily injured by drouth, not recovering well when rains do come. Under favorable conditions it ratoons fairly well. It is, however, exceedingly susceptible to mosaic disease and is very badly injured by it. At one time it was the leading cane in Barbados and it has been largely planted in Jamaica and the smaller islands. Its record has been very uneven, sometimes standing well toward the head of the list as a sugar producer and at others falling comparatively low. This uncertainty of performance has caused it to lose ground in all quarters and it is less planted than it was six or eight years ago. It certainly would be an unsafe cane to plant for the main crop, but in the hands of a skillful planter on suitable lands it would be profitable for late spring planting, especially in irrigated districts where it need not suffer from drouth. Its local record follows:

COWGILL, Annual Report 3: 9, 1915. In red shale hills. Plant, 38.4 tons; 1st ratoon, 28.7; 2nd ratoon, 15.05; sucrose, 17.13; purity, 91.7.

Annual Report 25, 1917. Cut at 11 months. Plant, 25.30 tons; sucrose, 18.1; purity, 92.34; 6th in tonnage out of 9, but 1st in sucrose and purity.

Circular 8: 11, 1917. Plant, 30.46 tons; 1st ratoon, 15.30 tons; 2nd ratoon, 24.37 tons; sucrose, 14.90; purity, 91.5

MCCONNIE, Revista de Agric., 1: 15, 1918. 11th in total sugar out of 25 kinds. Average of 3 crops, 22.61 tons; sucrose, 13.2; purity, 89.7; total suagr, 2.97 tons.

B-347—Parentage Unknown.

(Also known as B-306.)

This is another good average cane, but apparently without any special characteristics that would warrant its continued planting. It is quite resistant to root disease as shown by its unusually good ratooning ability. Its behavior as regards the mosaic disease has not been determined. The foliage seems particularly subject to some of the leaf-spot diseases. In 1912 it was reported as being much planted in Trinidad, but as early as 1906 it was discarded in Jamaica as not worthy of further trial. It seems to have attracted but little attention in the other islands. Its record here is fragmentary. Cowgill, 5th Ann. Rept. 23, 1917, reports a mill run on a lot of 16 cars which gave 1 per cent more sucrose and 3 per cent higher purity than the mill run for that day.

Cowgill, Circular 8: 12, 1917. Plant cane, 24.42 tons; sucrose and purity not given.

McConnie, Revista de Agric., 1:16, 1918. 16th in total sugar out of 25 kinds. Average of 3 crops, 22.6 tons; sucrose, 11.8 per cent; purity, 84.3 per cent; tons of sugar, 2.58.

B-376—Parentage Unknown.

This cane is so much like Crystalina in both botanical and cultural characters that it is difficult to find any technical point by which to distinguish them. Clearly it must have been a chance seedling from the Crystalina. It is, if any difference, an even better ratooner than Crystalina, but does not resist the mosaic disease quite so well. It has a long record in the Barbados reports, being formerly largely planted there and frequently taking first or second place in sugar yield, especially as old ratoons on red lands. In St. Kitts and Nevis as late as 1916 it was reported as becoming popular on account of heavy tonnage. In sucrose and purity it about equals Crystalina and has quite uniformly exceeded it in tonnage both here and in the other islands. Considering it simply as an improved Crystalina, its further planting seems decidedly advisable. Its published record here follows:

Cowgill, Insular Station, Circ. 8: 11, 1917. Plant, 39.37 tons; 1st ratoon, 30.35 tons; 2nd ratoon, 14.40 tons; sucrose, 16.68 per cent; purity, 91.4 per cent.

McConnie, Revista de Agric., 1: 16, 1918. 11th in total sugar out of 25 kinds. Average of 3 crops, 27.89 tons; sucrose, 12.1 per cent; purity, 87.5 per cent; tons sugar, 3.29.

B-1809—PARENTAGE UNKNOWN.

This is another very good cane, but with nothing in its record to specifically recommend it. It grows well and ratoons well, but it is rather susceptible to the mosaic disease. Sucrose and purity are good. It has figured but little in reports from the other islands. It is not sufficiently tested here for a final judgment.

COWGILL, Annual Report, 23, 1917. Plant, 23.70 tons; 1st ratoon, 17.35 tons; sucrose, 16.5 per cent; purity, 87.81 per cent.

Annual Report, 5: 24, 1917. 4th in combined tonnage out of 20 kinds. Combined plant and 1st ratoon, 46.50 tons; sucrose, 16.43 per cent; purity, 91.13 per cent.

Plant cane cut at 11 months. 7th out of 9 kinds. Plant, 23.70 tons; sucrose, 14.7 per cent; purity, 82.5 per cent.

B-3405—A SEEDLING OF D-74.

This is another good cane that has not been sufficiently tested here to make a final judgment possible. As second ratoons it is now (March, 1919) making the best showing of any of the kinds in the variety plots at the Insular Station. It evidently is highly resistant to root disease, but its susceptibility to mosaic has not been determined. In the Barbados reports it for many years took a high place as a cane for red lands, especially ratoons, but always took a much lower place when grown on black lands. It certainly should be given a wider trial here, especially as a cane for upland planting. It gives promise of succeeding on those lands where Cavangerie is now so widely planted and it is decidedly a better cane.

COWGILL, Annual Rept. 5:24, 1917. 4th in total tonnage in a lot of 20 kinds. Combined plant and 1st ratoon, 54.90 tons; sucrose, 16.17 per cent; purity, 90.61 per cent.

MCCONNIE, Revista de Agric., 1: 16, 1918. 20th in total sugar out of 25 kinds. Average of 3 crops, 20.43 tons; 12.3 per cent sucrose; purity, 85.2 per cent; total sugar, 2.49 tons.

B-3412—SEEDLING OF D-74.

(*Also known in Porto Rico as Sealey's Seedling.*)

This cane is planted quite extensively on hill lands especially by Centrals Guánica and Fajardo. On low lands it gives heavy tonnage, but it ripens so slowly that it is usually poor in sucrose and purity. It is a long-season cane and should always be planted in the fall as *gran cultura*. While quite resistant to root disease and ratooning well, it is very susceptible to mosaic disease and should

not be planted where this is prevalent. It is never a very sweet cane, but becomes fairly good when fully mature. Its slender diameter is objected to by some, but it suckers so freely as to put it in the first rank as regards tonnage. It is not a general-purpose cane, but can be used to advantage by those who understand it. It long held a prominent place in Barbados, especially in the red lands, where it frequently headed the list in total sugar production. Sealey's Seedling is considered distinct in Barbados, but the cane grown here under that name cannot be distinguished from B-3412. Its local record follows:

COWGILL, Insular Experiment Station Circ. 8: 11, 1917 (as Seeley's Seedling). Plant, 45.85 tons; 1st ratoon, 36.35 tons; 2nd ratoon, 25.95 tons; sucrose, 14.85 per cent; purity, 89.1 per cent.

MCCONNIE, Revista de Agric., 1: 15, 1918. 3rd in total sugar out of 25 kinds. Average of 3 crops, 33.25 tons; sucrose, 12.1 per cent; purity, 84.6 per cent; total sugar, 3.96 tons.

Ibed., 17 (as Seeley's Seedling). 17th out of 25 kinds. Average of 3 crops, 26.21 tons; sucrose, 10.80 per cent; purity, 84 per cent; total sugar, 2.81 tons.

B-3922—SEEDLING OF B-647.

This has been one of the favorite canes at Central Guánica, where under irrigation it has given very satisfactory yields. In other parts of the Island it has not attracted much attention. In both the Mayagüez and Río Piedras experimental plots it is only a fair ratooner. Unfortunately, it is so seriously injured by the mosaic disease that its cultivation will have to be abandoned where that prevails. It is a good milling cane with at least average sucrose and purity. At one time it was largely planted in Barbados, where it frequently took first place as a sugar producer on red lands both as plant and ratoons. It never did so well in the black-land trials. It seems to be another cane only well adapted to certain conditions and it should only be planted by those who understand its capabilities. Its only published record in Porto Rico follows:

MCCONNIE, Revista de Agric., 1: 16, 1918. 23 in total sugar out of 25 kinds. Average of 2 crops, 16.63 tons; sucrose, 12.7 per cent; purity, 89.1 per cent; tons of sugar, 2.10.

B-4596—SEEDLING OF B-521.

This cane has attracted attention on account of supposed immunity to the mosaic disease. This, however, has not been substantiated by the immunity experiment at Santa Rita, where this kind

has fallen below Rayada in resistance. It is a strong growing cane, especially on heavy moist lands, and it is a good ratooner, but it is low in sucrose and purity and seems to have nothing to recommend it for general planting. Its record in the other islands is only ordinary, though it has taken first place in Antigua out of a test of 41 kinds. Its record here follows:

COWGILL, Annual Rept. 25, 1917. Lowest in lot of 9 kinds. Plant, 20.80 tons; 1st ratoon, 12.40 tons; sucrose, 12.80 per cent; purity, 81.30 per cent.

Circular 8: 11, 1917. 5th out of 25 kinds. Plant, 51.93 tons; 1st ratoon, 34.87 tons; 2nd ratoon, 21.70 tons; sucrose, 12.73 per cent; purity, 84.2 per cent.

MCCONNIE, Revista de Agric., 1: 16, 1918. 9th in total sugar out of 25 kinds. Average of 2 crops, 30.52 tons. Sucrose, 11.3 per cent; purity, 84.4 per cent; tons sugar, 3.37.

B–6292—SEEDLING OF T–24.

A slender but vigorous and productive cane with good sucrose and purity, but it has nowhere attracted any very serious attention. It seems best adapted to heavy black lands. It ratoons fairly well, but is more injured by the mosaic disease than the Rayada. It is seldom mentioned in the literature from the other islands, but here its record is decidedly above the average and it is well worthy of further trial except in locations infected with mosaic disease.

COWGILL, Annual Rept. 23, 1917. 2nd in tonnage out of 9 kinds. Plant, 28.85 tons; 1st ratoon, 17.95 tons; sucrose, 14.65 per cent; purity, 85.78 per cent.

COWGILL, Annual Report, 5: 24. 2nd place in combined tonnage out of 20 kinds. Plant and 1st ratoon, 62.70 tons; sucrose, 15.97 per cent; purity, 91.37 per cent.

COWGILL, *ibed* : 25. 3d place in list of 9 kinds cut at 11 months. Plant, 28.85 tons; sucrose, 12.3 per cent; purity, 80.9 per cent.

B–6450—SEEDLING OF T–24.

As shown by Mr. Bovell's letter printed on another page, this is the only one of the Barbados seedlings mentioned in this paper that is still cultivated to any extent in that island. For a number of years it held first place there and was very widely planted, but now it is being superceded by even better kinds. It seems particularly well adapted to black lands though it has taken first place on both red and black lands in Bardados, showing it to be adapted to a fairly wide range of conditions. It is a good milling cane, with

better than the average sucrose and purity. It ratoons well and is fortunately more resistent to mosaic disease than Rayada, being equal to D-117 in this respect. It is safe to urge the wider planting of these two kinds. Its only Porto Rican record is—

McCONNIE, Revista de Agric., 1: 15, 1918. 7th in total sugar out of 25 kinds. Average of 3 crops, 29.62 tons; sucrose, 11.8 per cent; purity, 85.8; total sugar, 3.48 tons.

THE PORTO RICAN SEEDLINGS.

The first two hundred numbers put out under the initials P. R. were bred at the Federal Station at Mayagüez. On the establishment of the Sugar Station, now the Insular Experiment Station at Río Piedras, the work of growing cane seedlings at Mayagüez was abandoned. It has since been resumed there, the later kinds being numbered under the initials M. P. R. Of the first series none seem to have established themselves in general cultivation, though a few are still found in experimental collections. The kinds bred at the Insular Station at Río Piedras have been given the initials P. R. with numbers above 200. The numbers used now run above 500 and the kinds selected from the last two years' seed beds have not yet received permanent numbers. Seed cane of 15 of the earlier of these seedlings has been sent out quite widely to plantations in all parts of the Island. So far none of them have come into general cultivation, and unfortunately in most cases they have not been kept separate from the other plantation canes so no very positive results can be expected from this distribution. It seems unwise to distribute new kinds promiscuously. The better policy would be to keep them in the hands of a few interested parties for testing under diverse conditions until they can be specifically recommended as markedly better than existing kinds at least for special purposes. These are all good canes. Doubtless in certain cases each of them has given better results than the Rayada or Cristalina. Their botanical description will be found in the second part of this paper, but it seems unwise to attempt to discuss their cultural characteristics until more is really known regarding them. In passing it may be observed that P. R.-292 seems one of the most promising of the lot especially as to ratooning power, while P. R.-210 is deficient in this respect. This kind, however, and P. R.-260 are more resistant to the mosaic disease than is the Rayada. No performance records of these kinds have been published.

The Guánica Seedlings.

For the past ten or twelve years the Central Guánica has each year grown a large number of seedling canes and over a thousand of these have been selected for a further planting and study. These canes are numbered under the initials G. C. A considerable number of them are now being planted on a large scale on the various Guánica estates and are giving fine results. A few have been more or less distributed, but only four are included in the descriptive part of this paper. Of these G. C.–493 and G. C.–701 are being planted on a large plantation scale. Both are good canes, but the former suffers severely from attacks of mosaic disease while G. C.–701 is fully as resistant as Rayada or perhaps even a little better in this respect. G. C.–1480 and G. C.–1486 have so far only been planted on an experimental scale, but, both at Mayagüez and at Santa Rita, they show unusually good resistance to the mosaic disease, being only surpassed in this respect by the Java canes. Their ratooning power is good, and as shown by the plots at Mayagüez they are unusually well adapted to heavy compact, wet soils. They are well worthy of extended trial for such locations. Other G. C. canes showing great resistance to mosaic are numbers 888, 1180, 1313, 1513, 1519, 1521, 1522 and 1545.

The Fajardo Seedlings.

Central Fajardo has also grown a large number of seedlings and has selected and is testing several hundred of them. Some of them are being largely planted on a field scale at Fajardo, but they have not been disseminated and so are not included in this paper.

The Immune Japanese Cane Kavangire.

In a recent paper [1] the writer has called attention to the absolute immunity of this variety to the mosaic disease. The variety plots at the Federal Station at Mayagüez where this kind was first seen have now been cut for some weeks and a recent inspection of the ratoons shows that it is also resistant to root disease in a very marked degree. The stand is perfect and the ratoons are growing much more vigorously than any of the other 44 kinds in these plots. From what has been seen of it here and with its splendid record in the Argentine

[1] An Immune Variety of Sugar Cane. This paper was published in Spanish in the daily press of San Juan, but an abstract in English prepared by Dr. C. O. Townsend appeared in *Science*.

it seems certain that it will out-yield and out-ratoon any of the kinds now in general cultivation. On the high, dry uplands it should replace Cavengerie, and its record at Mayagüez shows it equally well adapted to the heavy, compact, low lands where the Yellow Caledonia is now gaining so rapidly in popularity. It is a long-season cane and slow in maturing. It should therefore be planted in the fall as *gran cultura.* When fully matured it will average at least as high in sucrose and purity as the Caledonia and decidedly better than the Cavengcrie. The finding of this cane at this time seems to promise much for the future of the sugar industry in Porto Rico. Its slender diameter will at first be unpopular but after all it is total sugar per acre that interests us and not the diameter of the cane.

The Java Seedlings.

When the Kavangire was brought from the Argentine by the Mayagüez Station, the Java seedlings Nos. 56, 228 and 234 were also introduced from the same source. These are all slender canes, clearly showing the North Indian type of the Chunnee variety which has been used as the pollinating parent in so many of the Java crosses. While in no sense immune to the mosaic disease like the Kavangire, they are highly resistant to its effects. In 56 and 234 particularly growth does not seem to be at all checked and the presence of the disease is only indicated by hardly noticeable discolorations of the leaves. These kinds are ratooning strongly in the Mayagüez plots indicating high resistance to root disease. Nos. 36 and 234 are two of the Java kinds now being almost exclusively planted in the Argentine where they are giving very much better results than the Rayada which was formerly the standard cane. They do not give quite such heavy tonnage as the Kavangire, but they are better in sucrose and purity and they mature earlier thus escaping injury from frost. From the description of number 36 it seems to be the same cane we have here under the No. 56. While the experience with these canes in Porto Rico is still limited to the experimental plots at the Mayagüez Station and the Guánica experimental fields at Santa Rita they are exceedingly promising and are worthy of much more extended trial, especially since their resistance to the mosaic disease is so marked that its presence can be practically disregarded. Their slender diameter will at first tend to make them unpopular with most growers.

DESCRIPTIONS OF SOME VARIETIES OF SUGAR CANE NOW GROWN IN PORTO RICO.

TAXONOMY OF CANE VARIETIES.

There are many published descriptions of cane varieties, but for the most part they are too brief and fragmentary to make them intelligibly comparable or of practical use in determining the kinds encountered. Cowgill[1] has published full descriptions of part of the kinds discussed in this paper. A part of the following has been transcribed from the data furnished from his article, but for the most part it represents direct field studies. The characters of the infloresence have not been considered. These would doubtless furnish many good points for distinguishing varieties, but in some years many of the kinds do not flower here, and when they do it is for only a short period. To be serviceable a classification should be based on characters that are always observable. In describing a variety data should be given on all of the following points: 1st, general habit, whether growing strongly erect or soon declined, or recumbent with a word as to comparative vigor; 2d, the stalk; whether thick or slender in diameter, numerous or few in the hill, color, and amount and character of bloom; 3d, under the internodes give comparative length, shape, direction, whether straight or staggard and the presence or absence of a furrow above the bud and its characters if present; 4th, the nodes furnish important characters. The first element is the limiting ring which divides the node from the internode. It may be broad or narrow, elevated or sunken, concolorous or differently colored from the internode. Below this comes the root band showing the rudimentary roots. Both these elements are really a part of the internode above. Next comes the bud, which requires a separate heading, and then the leaf scar. In a few varieties this is conspicuously cilliate, but it is usually glabrous. It may be long or short and may project equally on all sides or be appressed closely behind—on the side opposite the bud. Still below this is the glaucous band, which is usually quite conspicuous but may be obscured by blending with the bloom of the internode. 5th. are the buds which give striking and fairly constant characters, but it must always be remembered that those change with age and condition of development. These may be large or small; longer than broad, either oval or ovate and sharp pointed or obtuse; they may be triangular or subtriangular with the base rounded and about as broad

[1] See bibliography

as long; or they may be orbicular or hemispheric. The point may be closely appressed to the stalk or prominently elevated. They may remain long dormant or may soon partially develop on the stalk. The margin may be wide or narrow, uniform or shouldered, The base or apex or both may be bearded or the entire bud be nearly glabrate. Other good characters could be obtained from the shape and texture of the dissected bud scales, and this would be necessary in handling a large number of kinds. 6th. The leaf sheath yields useful characters. One of the most obvious is the presence or comparative absence of a vestiture of stiff hairs on the back. The shape of the shoulders or auricles should be noted and whether one or both has a pointed lobe, though this is a variable character. The throat at the top of the sheath where it joins the leaf usually has a vestiture of long hairs. The ligule, the hard membrane that fits against the stalks at the base of the leaf, may be long or short, uniform in width or with the center elevated or depressed and the edge may be even or conspicuously fimbriate. On the back where the leaf joins the sheath is a discolored area, or rather two triangular areas, that may or may not reach the midrib and coalesce, which may be called the collar. It may be dark brown or pallid in color and either glaucous or lannate. 7th. The leaves also give good characters. Their abundance, position, color, width and general shape should be noted and especially the character of the serrations on the margin and whether these reach the base and whether or not the margin at the base is cilliate. With careful notes on these points it will be possible to determine the varieties quite accurately by the following key:

The nomenclature and synonomy of the older varieties is almost hopelessly involved. No two authors fully agree. It can never be satisfactorily straightened out without a first-hand study of authentic material on some such basis as the above.

KEY TO THE VARIETIES.

1. Stalks conspicuously striped, green or yellow and red .... Rayada
   Stalks reddish or brownish red or purple 2
   Stalks at first green becoming tinted with red, pink, or violet when exposed 6
   Stalks at first green then yellowish with no tint of red 26
2. Leaf sheaths with faint longitudinal stripes, stalks often with occasional faint blackish stripes .... Cavengerie
   Leaf sheaths and stalks not striped 3

3.	Stalks medium to large diameter	4
	Stalks slender, numerous	5
4.	Buds ovate or oval, apex bearded	D-109
	Buds broader than long, glabate	D-448
5.	Buds broadly oval, margin uniform. Stalk without heavy bloom	Java 53
	Buds obovate the margin shouldered above. Stalks with heavy bloom	Java 228
6.	Leaf scar conspicuously cilliate	B-3922
	Leaf scar glabrous	7
7.	Leaf sheath glabrate, the vestiture confined to the median line	8
	Leaf sheath with effused vestiture of stiff hairs	12
8.	Cane very slender, buds small, orbicule	Java 234
	Cane of medium to large diameter	9
9.	Buds with margin conspicuously shouldered or lobed	10
	Buds with margin of uniform width	11
10.	Collar lannate, reaching the midrib	Crystalina
	Collar glaucous, not reaching the midrib	B-376
11.	Internodes long, cylindrical, the surface marked by checks and lines	Yellow Caledonia
	Internodes short, tumid, not marked by checks and lines	P. R.-318
12.	Buds longer than broad, usually ovate and pointed	13
	Buds as broad as long, subtriangular or orbicular	18
13.	Vestiture of leaf sheath soon decidous, becoming glabrate	P. R.-230
	Vestiture of leaf sheath persistent	14
14.	Buds closely appressed, not developing in the standing stalks	15
	Buds soon developed and prominently excerted	16
15.	Margin of bud narrow, uniform	B-347
	Margin of bud broad, shouldered	B-4593
16.	Stalk medium to large in diameter	B-3405
	Stalk rather slender	17
17.	Ligule short	B-3412
	Ligule long	B-6292
18.	Buds triangular or subtriangular, pointed	19
	Buds semi-orbicular, obtuse	23
19.	Leaf sheath with scanty deciduous vestiture, soon glabrate	P. R.-207
	Leaf sheaths with persistent vestiture	20
20.	Leaf scar about equal on all sides, not appressed behind	21
	Leaf scar appressed behind	22
21.	Nodes not constricted, limiting ring poorly defined	P. R.-271
	Nodes constricted above the bud, limiting ring prominent	P. R.-292
22.	Internodes long, subcylindrical, quite glaucous	G. C.-1480
	Internodes tumid, inequilateral, not conspicuously glaucous	G. C.-1486
23.	Nodes conspicuously constricted below the bud	P. R.-309
	Nodes scarcely constricted	24
24.	Stalks glaucous with heavy bloom	D-433
	Stalks glabrous, not glaucous	25
25.	Buds large, margin shouldered	P. R.-209
	Buds small, margin uniform	P. R.-270
26.	Leaf scar heavily cilliate	G. C.-701
	Leaf scar glabrous	27

27.	Leaf sheath glabrate, or with vestiture confined to median line	28
	Leaf sheath with effused vestiture	30
28.	Buds oval, narrowed below, stalks very slender	Kavangire
	Buds triangular, margin narrow, uniform	B–109
	Buds hemispheric	29
29.	Leaves erect except extreme tip, broad	P. R.–202
	Leaves declined, narrow	G. C.–493
30.	Buds oval or ovate, longer than broad	31
	Buds triangular or subtriangular	34
	Buds hemispheric	38
31.	Internodes with furrow very slight or none	32
	Internodes with furrow well marked	33
32.	Nodes oblique, root band broad, glaucous band conspicuous	P. R.–317
	Nodes not oblique, root band medium, glaucous band poorly defined	P. R.–219
33.	Stalk glaucous with a heavy bloom	P. R.–260
	Stalk glabrous, not glaucous except the glaucous band	Otaheite
34.	Limiting ring broad, reddish brown	D–625
	Limiting ring concolorous or nearly so	35
35.	Nodes medium length, constricted both above and below the leaf scar	36
	Nodes long, slightly constricted below leaf scar only	37
36.	Bud with narrow uniform margin	B–6450
	Bud with margin broadest in middle	P. R.–208
37.	Leaves erect, rather broad	B–1809
	Leaves spreading or declined, medium width	D–117
38.	Leaves stritcly erect, narrow	P. R.–210
	Leaves with the tips declined, broad	39
39.	Nodes broad, prominent; stalk not glaucous	P. R.–308
	Nodes small, constricted; stalks glaucous	B–208

RAYADA.

Habit erect or at length recumbent, vigorous. Stalks medium, diameter, longitudinally striped with irregular bands of purplish-red and yellowish-green, usually quite glaucous, color variable.

Internodes variable in length, usually tumid. Straight or little staggered. Furrow evident, medium depth and width.

Nodes more or less oblique, constricted; root band narrow, oblique, widest on side of bud, usually spotted with purple; rudimentary roots in about 3 rows, purplish or the centers purple; limiting ring broad, conspicuous, somewhat elevated; leaf scar glabrous, prominent in front, closely appressed behind; glaucous band usually conspicuous and decidedly constricted.

Buds medium size, subtriangular with rounded base, at first flat but soon plump and often tardily developing. Margin broad, the sides shouldered, cilliate at base and apex.

Sheaths glabrate, glaucous, with a few stiff hairs on medial line; shoulders medium width; throat densely lannate, the vestiture of medium course hairs mainly on shoulders and margin; ligule medium width, entire; collar conspicuous, reaching the midrib, lannate.

Leaves abundant, spreading, the tips declined, medium length and width, long accuminate, serrulate above, margin even below and the base cilliate.

This cane is practically indistinguishable from Crystalina except in color. Taxonomy conforms the view that one is only a color variant of the other.

Cavengerie.

Habit erect or at length somewhat declined, vigorous. Cane medium height and diameter, dark wine-red, often with faint darker longitudinal stripes.

Internodes medium to long, nearly cylindrical, often somewhat staggered; furrow shallow.

Nodes narrow, somewhat constricted; root band narrow, somewhat constricted; rudimentary roots purplish, in about 3 rows; limiting ring broad, somewhat elevated, yellowish when young, but becoming reddish with age; leaf scar glabrous, often oblique; glaucous band narrow, somewhat constricted.

Buds dark colored, small, ovate, plump, but not developing, obtuse; margin narrow, uniform; base usually appressed cilliate, sometimes glabrate throughout.

Leaf-sheaths reddish-green, usually with faint whitish longitudinal stripes; vestiture dense, of stiff hairs; shoulders narrow; throat with vestiture of rather short hairs; ligule narrow, turned inward, center retuse.

Leaves erect except the tips, abundant, rather short, tapering abruptly, margin cilliate below.

D–109.

Habit inclined to recumbent: Stalks long, medium diameter, dark purple, glaucous.

Internodes medium to long, slightly flattened, usually tumid, especially below; furrow shallow or none.

Nodes medium to small, regular, darker than the internodes with age, but lighter when young; root band narrow; rudimentary roots in 2 to 3 rows; leaf scar glabrate; glaucous band somewhat constricted.

Buds oval to ovate, plump, soon expanded; margin narrow, obtuse; apex bearded.

Leaf sheaths subglabrate, very glaucous, usually reddish; shoulders medium, one side often pointed; throat lannate and with soft hairs on shoulders and leaf margin; ligule short, the center somewhat pointed.

Leaves spreading, abundant, dark green, medium width and length, long pointed.

D–448.

Habit erect, tall, vigorous. Stalk medium to large diameter, wine color, fading to brownish on long exposure, somewhat glaucous.

Internodes medium to short, cylindrical or often tumid below; furrow none.

Nodes scarcely constricted; root band narrow; rudimentary roots crowded, dark wine color, in 3 or 4 irregular rows but massed toward upper side of band; limiting ring conspicuous, yellowish, sunken; leaf scar glabrous, medium width, appressed behind, glaucous band well marked, not constricted.

Buds large, broader than long; apex rounded, plump, often developing; margin nearly uniform, of medium width, glabrate.

Sheaths glabrate, stained with purple; shoulders medium, not often lobed; throat lannate, also abundant but rather short vestiture especially on shoulders; ligule medium width, broadest at middel, even; collar rather faint, reaching the midrib, glaucous.

Leaves erect or the tips declined, rather broad, bright green, minutely serrulate above, even and cilliate margined below. It arrows freely.

JAVA–56 [1]

Habit suberect, vigorous. Stalks slender, numerous, brownish purple, not glaucous.

Internodes long, straight, cylindrical; furrow scarcely evident.

Nodes broad, prominent, not constricted; limiting ring narrow, conspicuous, greenish; root band broad; rudimentary roots inconspicuous, purplish in about 3 rows; leaf scar glabrous; glaucous band conspicuous but not constricted.

Buds large, oval, broader than long, obtuse, at first appressd then prominent; margin broad, uniform.

Leaf sheaths glabrate, purplish; throat minutely lannate and with scanty vestiture of hairs; ligule abruptly broadest at center; collar narrow, inconspicuous, not reaching the midrib.

Leaves declined, narrow long accuminate weakly serrulate to base.

JAVA–226.

Habit erect, vigorous. Stalks slender, numerous, purplish, with heavy bluish bloom.

Internodes long, cylindrical, straight; furrow scarcely evident.

Nodes tumid, broad; limiting ring elevated, broad, yellow then dark brown; root band broad, palid; rudimentary roots in 3 or 4 rows; leaf scar glabreous, medium width, appressed behind; glaucous band tumid, larger than the internode.

Buds obovate, broad, appressed, then rather prominent; margin wide and shouldered above; apex and base barbed.

Leaf sheaths glabrate, the shoulders unequal; throat lannate but with sparing vestiture of hairs; ligule broad, the margin minutely fimbriate; collar inconspicuous, glaucous.

[1] Probably an error, as it seems to be the same as Java–36 of the Argentine, which is not the original J–36 of Java.

Leaves erect, the tips declined, narrow, minutely and distinctly serrulate.

B-3922.

Habit erect or subdeclined, many stalks, vigorous; stalks green, the epidemris checking, becoming tinged with red when exposed.

Internodes long, cylindrical, almost straight, the upper half lined by cracks in the epidermis; furrow slight but evident.

Nodes prominent, scarcely constricted; root band medium; rudimentary roots white, in about 3 rows; limiting ring obscure; leaf scar conspicuously cilliate; glaucous band conspicuous; scarcely sunken.

Buds broadly triangular, appressed, at length prominent. Margin and obtuse apex with scanty appressed barbs.

Leaf sheaths with scanty and short vestiture, especially above; shoulders broad, equal, not lobed; throat with scanty vestiture but extending into shoulders and leaf margins; ligule prominent, broadest in middle; collar minutely floccose-lannate.

Leaves declined, minutely serrulate above, even and somewhat ciliate below.

JAVA-324.

Habit erect subdeclined. Stalks numerous, slender, dull greenish, tinted reddish on exposure.

Internodes long, cylindrical or slightly enlarged below, straight; furrow scarcely evident.

Nodes broad, enlarged; limiting ring broad, yellowish, not elevated; root band broad, tumid; rudimentary roots obscure, scarcely evident; leaf scar narrow, appressed behind; glaucous band clearly marked but not constricted.

Buds small, orbicular, becoming hemispheric, glabrous.

Leaf sheaths glabrous; throat lannate but with scanty vestiture of hairs; ligule very broad, minutely fimbriate; collar inconspicuous; glaucous.

Leaves declined, numerous, narrow, hanging long on the stalk, slightly serulate, the serrations distinct and the points closely appressed.

CRYSTALINA.

Habit erect to declined or recumbent, vigorous. Stalks medium diameter, grenish or yellowish with shades of pink or lilac when exposed; quite glaucous.

Internodes medium to long, often somewhat tumid, usually straight or not conspicuously staggered; furrow evident, medium depth.

Nodes oblique, constricted; root band narrow, oblique, narrowed behind, slightly constricted; rudimentary roots small, inconspicuous, palid with brownish centers, in about 3 rows; limiting ring conspicuous, yellowish green, elevated; leaf scar glabrous, wide in front, closely appressed behind; glaucous band constricted,

rather narrow, not very conspicuous, often blending with the bloom of the internode.

Buds medium size, subtriangular with rounded base, at first flat but becoming plump at maturity, tardily developing; border wide with the sides shouldered; base and apex appressed-cilliate.

Sheaths glabrate, usually with a few hairs on the central line, quite glaucous; shoulders medium width; throat densely lannate and with medium vestiture of coarse hairs; ligule medium width, entire; collar conspicuous, reaching the midrib, lannate throughout.

Leaves abundant, spreading, the tips declined, medium length and width, flat, long acuminate, bright green, minutely cilliate for two or three inches at base.

B-376.

Habit erect, then reclined or recumbent. Stalks numerous, medium diameter, color greenish or yellowish, with varying tints of pink or red or lilac when exposed, glaucous.

Internodes of medium length, cylindrical or somewhat tumid, straight or slightly staggered; furrow of medium depth.

Nodes oblique, constricted; limiting ring conspicuous, yellowish green, elevated; root band narrow, oblique, narrowed behind, but little constricted; rudimentary roots inconspicuous, in about 3 rows, leaf scar glabrate, wide in front, appressed behind; glaucous band constricted, not conspicuous, blending with the bloom of the internode.

Buds medium size, subtriangular, with rounded base, plump at maturity but developing tardily; border wide with shouldered sides; base and apex cilliate.

Leaf sheaths glabrate, a few hairs on median line, glaucous; shoulders medium; throat lannate with a medium vestiture of coarse hairs; ligule medium to broad; collar not reaching the midrib, glaucous but not lannate, or sometimes very slightly so, near the margin.

Leaves abundant, spreading, the tips declined, medium green, minutely serrulate above, even below and the base cilliate.

Can scarcely be distinguished from Crystalina except by the glabrous collar. In Crystalina the collar is lannate to the midrib.

Yellow Caledonia.

Habit erect, stout, vigorous. Stalks green, yellow when mature, tinted with red where fully exposed; not glaucous.

Internodes long, straight, cylindrical; furrow none, marked with numerous vertical lines or checks in the epidermis.

Nodes short, not constricted; root band narrow; rudimentary roots small, reddish, in about 3 rows; limiting ring broad, conspicuous, greenish or sometimes purplish, even, not elevated; leaf scar

glabrous, narrow, appressed behind; glaucous band conspicuous, not sunken.

Buds small, often purplish, suborbicular, slightly pointed, the point slightly elevated, margin narrow, uniform, base glabrate; margin and apex cilliate, not developing.

Sheaths glaucous, glabrate; shoulders narrow seldom lobed; vestiture of throat scanty, but the shoulders cilliate on margins; ligule medium width, margin even; collar well marked, reaching the midrib, lannate.

Leaves erect except the tips, broad, somewhat plicate, minutely serrulate above, smooth and margin cilliate below.

One of the most vigorous and best marked varieties. The inside of the base of the leaf sheath has a lilac or purplish tint.

P. R.-318.

Habit somewhat declined. Stalks heavy, yellowish green, tinted with red on full exposure.

Internodes medium to short, thick, somewhat tumid, slightly staggered; furrow none or very slight.

Nodes broad, subconstricted; root band medium; rudimentary roots whitish, in about 3 rows; limiting ring conspicuous, darker green; leaf scar glabrous, conspicuous, not appressed behind; glaucous band broad, pale, scarcely constricted.

Buds broad, subtriangular, appressed with prominent obtuse apex, margin broad, nearly equal; base and apex minutely barbate.

Leaf sheath subglabrous with inconspicuous vestiture confined to the median line; shoulders uniform or sometimes one of them lobed; throat lannate and with abundant vestiture which reaches the midrib; ligule broad, even; collar conspicuous, brown, lannate.

Leaves erect with tips declined, broad, sharply serrulate to the base.

P. R.-230.

Habit erect, vigorous. Stalks numerous, straight, green, pinkish when fully exposed, not glaucous.

Internodes long, cylindrical, medium diameter, straight or slightly staggered; furrows none or very slight below.

Nodes scarcely constricted; root band broad; rudimentary roots large, whitish with brown centers, in about 3 widely spaced rows; limiting ring broad, brown, elevated; scar glabrous, medium width, appressed behind; glaucous band poorly defined, inconspicuous.

Buds large, broadly ovate, soon expanding and prominent, broad-margined; base minutely appressed, cilliate; tip glabrous.

Sheaths at first with moderate whitish vestiture which is soon deciduous, leaving old sheaths glabrate; shoulders narrow, one often acutely lobed; throat lannate, vestiture short, scanty; ligule medium width, subfimbriate; collar broad, reaching the midrib, pale brown, glaucous.

Leaves erect with the tips declined, long, medium width, bright green, minutely serrulate, nearly but not quite to base; margins at base somewhat cilliate.

B-347.

Habit erect to reclining. Stalks medium to large diameter, yellowish-green with a tinge of red when exposed; somewhat glaucous.

Internodes of medium length, slightly flattened, usually staggered, often marked with irregular light-colored spots.

Nodes medium to large; root band somewhat constricted; rudimentary roots in two to five rows; leaf scar glabrous, prominent on all sides, not appressed behind.

Buds long, ovate or oval, appressed; margin narrow.

Leaf sheath with vestiture of long, soft setæ; throat lannate and with a medium vestiture of long, soft hairs.

Leaves suberect, medium width, rather short, the edges usually curled, rather light green.

B-4596.

Habit erect to reclined. Stalks large, medium length, yellowish green to reddish green, sometimes spotted with reddish brown, glaucous; the epidermis cracked in fine lines.

Internodes medium to long. somewhat flattened, often enlarged below, slightly tumid; furrow medium.

Nodes rather short; root band narrow; rudimentary roots in 2 rows; leaf scar glabrate; glaucous band constricted, conspicuous.

Buds typically large and course, broad, obtuse or sometimes pointed, margin wide, with large lobes, occasionally developing and becoming excerted but not sprouting.

Leaf sheaths with vestiture of medium short, fine, stiff setæ; shoulders small; ligule medium, rounded or center depressed; throat with vestiture on the shoulders, margins and adjacent leaf surface.

Leaves medium, readily shed, rather broad.

B-3405.

Habit erect to inclined. Stalks long, medium diameter, reddish green, somewhat glaucous.

Internodes medium length, slightly flattened, tumid on side opposite bud, often somewhat staggered; furrow broad but shallow.

Nodes medium; root band rather broad; rudimentary roots in 2 to 3 rows, leaf scar glabrous, oblique, prominent below the bud, appressed behind; glaucous band slightly constricted.

Buds semi-elliptic to ovate; margin nearly uniform, soon expanded and prominent; sides and apex barbate.

Leaf sheaths with conspicuous vestiture of medium stiff setæ; shoulders medium to large; throat with vestiture of long course hairs; ligule medium width.

Leaves narrow, light green, long accuminate.

B-3412.

Habit erect to inclined. Canes numerous, long, slender, green, becoming reddish on exposure.
Internodes medium to long, cylindrical, straight or very slightly staggered; furrow evident.
Nodes medium size, slightly oblique; root band not constricted; rudimentary roots in about 3 rows; leaf scar glabrate; glaucous band constricted, well marked.
Buds large, triangular or broadly ovate, acute; margin of medium width; soon expanding and becoming prominently excerted; the apex bearded.
Leaf sheaths with abundant vestiture of stiff setæ; throat lannate and with a medium vestiture of coarse hairs; ligule narrow, entire; collar glaucous or minutely lannate, not reaching the midrib.
Leaves narrow, long accuminate, medium dark green.

B-6292.

Habit erect. Stalks long, slender, green then reddish green.
Internodes somewhat inequilateral, tumid on side opposite the bud; furrow shallow.
Nodes medium size, longest on side with bud; leaf scar glabrate; glaucous band constricted, conspicuous.
Buds elliptical with medium uniform margin, usually soon developing with the prominent acute point projecting through the bud scales.
Leaf sheaths with abundant vestiture; shoulders large, usually obtuse, sometimes one-pointed, broad, with vestiture on the shoulders and margins; ligule long, the edge rounded.
Leaves abundant, medium green, narrow, tapering with a long point.

P. R.-207.

Habit erect, vigorous. Stalk stout, green, faintly tinged with pink on full exposure.
Internodes short, thick, ventricose, nearly straight; furrow, none.
Nodes somewhat constricted; root band broad, rudimentary roots crowded, white, in 4 rows; limiting ring indistinct; leaf scar glabrous, prominent in front, appressed behind; glaucous band broad, conspicuous, constricted.
Buds large, broadly triangular, obtuse, soon prominently developed; base and apex cilliate.
Leaf sheath with scanty deciduous vestiture, soon subglabrate, glaucous; shoulders rather narrow, occasionally acutely lobed; throat densely appressed-lannate, vestiture of long hairs scanty, mostly on margin of lobes; ligule very narrow, edge nearly entire; collar prominent, reaching the midrib, glaucous but scarcely lannate.
Leaves erect, tips declined, broad, abundant, dark green, serrulate to the base.

P. R.-271.

Habit erect, vigorous. Stalk stout, green, yellow when exposed and at length sometimes pinkish, rather glaucous.

Internodes medium length, cylindrical; furrow none or very faint.

Nodes rather prominent, not constricted; root band narrow; rudimentary roots large, whitish, in 2 to 3 rows; limiting ring broad but indistinct and poorly defined, greenish; leaf scar glabrous, about uniform on all sides; glaucous band not constricted, poorly defined.

Buds medium size, broadly ovate or triangular, soon thick and prominent but not developed, densely cilliate at base and apex.

Sheaths with heavy stiff tawny vestiture; shoulders narrow, seldom lobed; throat with dense but short tawny vestiture; ligule very short, nearly even; collar conspicuous, reaching the midrib, dark brown, lannate.

Leaves erect almost to the tips, broad, dark green, serrulate to the base.

A good vigorous cane, conspicuous for its heavy dark tomentum and glaucous stalks.

P. R.-292.

Habit at length declined, vigorous. Stalks numerous, green with a heavy bloom, slightly tinted with red when exposed.

Internodes long, cylindrical, straight; furrow none or scarcely evident.

Nodes broad, constricted above the bud; root band broad; rudimentary roots in 3 to 4 rows; limiting ring prominent; leaf scar glabrous, nearly equal behind, not appressed; glaucous band poorly defined, obscured by bloom of the internode.

Buds short, subtriangular, obtuse, flat, with wide, somewhat lobed margin, at length developing and very prominent, often sprouting.

Leaf sheaths with heavy vestiture; shoulders square, not lobed; throat lannate but with scanty vestiture which reaches the midrib and the leaf margin; ligule very narrow, especially at the ends; collar pale brown, reaching the midrib, heavily glaucous.

Leaves erect with tips deflexed, broad, medium color. minutely serrulate above; margin at base ciliate.

G. C.-1480.

Habit erect, vigorous. Stalk stout, dull green tinted with red, quite glaucous.

Internodes long, subcylindrical, nearly straight; furrow well marked.

Nodes medium width, constricted; limiting ring depressed; root band narrow; rudimentary roots in 2 to 3 rows, often developing in the standing stalk; leaf scar glabrous, prominent, appressed behind; glaucous band poorly defined, blending with the bloom of the internode.

Buds large, ovate-triangular, acute, appressed but soon developed and prominent; margin broadest at base; apex and base barbed.
Leaf sheath with rather scanty vestiture; shoulders seldom lobed, throat with scanty vestiture and scarcely lannate; ligule short, even; collar glabrous.
Leaves erect with tips declined, broad, serrulate to base.

G. C.–1486.

Habit erect, vigorous. Stalks stout, green with red-brown tints when exposed, at length quite dark.
Internodes tumid, inequilateral, slightly staggered; furrow evident.
Nodes broad, somewhat constricted; root band broad; rudimentary roots in 3 or 4 rows, often developing on the standing cane; leaf scar glabrous, prominent, appressed behind; glaucous band well marked.
Buds large, triangular, appressed, then prominent; margin broad, inconspicuously lobed, glabrate.
Leaf sheaths with dense vestiture; throat with abundant vestiture extending up the leaf margins; ligule short, even; collar lannate, broad, the lobes brownish, the center pallid.
Leaves broad, crowded, short acuminate, sharply serrulate almost to base, margin cilliate at base.

P. R.–309.

Habit erect, vigorous. Canes numerous, large, dull green, dark pink when fully exposed.
Internodes rather long, medium diameter, slightly larger below, nearly straight; furrow none.
Nodes somewhat constricted below, medium width; root band medium; rudimentary roots large, reddish yellow, not conspicuous, in about 3 rows; limiting ring broad, elevated, greenish; leaf scar glabrous, not conspicuous, wider in front; glaucous band medium width, not conspicuous, constricted, forming the narrowest point in the stalk.
Buds medium to small, hemispheric with wide lateral margins, red dish, prominent but not developed; apex retuse, glabrous, the broad-shouldered margins cilliate, the base glabrate.
Leaf sheaths with an abundant vestiture of long, soft, whitish hairs; shoulders narrow, not lobed; throat with scanty vestiture; ligule narrow, entire; collar narrow, pale brown, scarcely reaching the midrib, lannate.
Leaves erect except the tips, broad, abundant, very minutely serrulate, the margin at base nearly even.

D–433.

Habit erect or at length declined, very vigorous. Canes numerous, medium diameter, gray-green, with some brownish or pinkish shades, densely glaucous.

Internodes medium length and thickness, cylindrical or slightly tumid below the middle; furrow none.

Nodes slightly constricted, narrow; root band constricted, narrow; rudimentary roots large but indistinct, whitish, crowded, in about 3 rows; leaf scar glabrous, short, appressed on all sides; glaucous band not constricted, poorly defined, blending wtih the heavy bloom of the internode.

Buds small, flat, closely appressed, suborbicular but pointed, not developing; apex densely cilliate with heavy tufts of hairs; base subglabrate.

Leaf sheaths with heavy vestiture of stiff hairs and densely glaucous; shoulders narrow, not lobed; throat with moderate vestiture, mostly on shoulders and margin; ligule narrow, retuse, edge cilliate; collar broad but poorly defined, reaching the midrib, glaucous.

Leaves erect, the tips declined, medium width, dark green, minutely serrulate almost to the cilliate base.

P. R.-209.

Habit erect, vigorous. Stalks numerous, green with a tinge, of pink, not glaucous.

Internodes short, stout, cylindrical, staggerrd; furrow none.

Nodes scarcely constricted, broad; root band broad; rudimentary roots large, yellowish, in about 3 rows; limiting ring broad, conspicuous, elevated, greenish; leaf scar glabrous, conspicuous, broad in front, appressed behind; glaucous band broad, well marked.

Buds large, hemispheric but somewhat pointed, prominent, soon somewhat developed; margin broad, shouldered; base and apex cilliate.

Sheaths with medium vestiture of stiff whitish hairs; shoulders broad, often lobed; throat with medium vestiture; ligule medium width, margin even; collar broad, dark, conspicuous, reaching the midrib, lannate.

Leaves erect except the tips, very broad, abundant, dark green, marginal serrations very minute, the lower half almost even.

P. R.-270.

Habit declined at base, vigorous. Stalks numerous, green becoming pink when exposed, not glaucous.

Internodes medium to short, medium diameter, cylindrical, slightly staggered; furrow none.

Nodes scarcely constricted; root band broad; rudimentary roots crowded, rather prominent, 3 or 4 rows; limiting ring indistinct; leaf scar glabrous, equally prominent on all sides, narrow; glaucous band rather broad, well amrked, slightly constricted.

Buds small, reddish, hemispheric, margin rather broad, uniform, subglabrous.

Sheaths with an abundant vestiture of short tawny hairs; shoulders broad, often lobed; throat with abundant vestiture; ligule very short, margin nearly even; collar conspicuous, nearly reaching the midrib, lannate.

Leaves erect, with the tips declined, often plicate and inrolled, medium width, serrulate to the base.

G. C.–701.

Habit erect or subdeclined. Stalks numerous, heavy, pale green.

Internodes medium, slightly constricted; root band narrow, rudimentary roots with brownish centers, in 2 or 3 rows; liimting ring conspicuous, elevated; leaf scar short, heavily cilliate with pallid hairs; glaucous band narrow, somewhat constricted.

Buds abovate, the margin shouldered above, at first flat, soon developing and prominent, often sprouting; apex and base minutely barbed.

Leaf sheaths with heavy vestiture; shoulders both lobed; throat lannate but with scanty vestiture; ligule medium width, nearly even; collar lannate.

Leaves declined, broad, serrulate throughout.

KAVANGIRE.

Habit subinclined, very vigorous. Stalks slender, very numerous, green, glaucous thruout.

Internodes long, cylindrical; furrow none.

Nodes broad, not constricted; root band broad; rudimentary roots scarcely showing; leaf scar glabrate, short; glaucous band not defined, blending with the bloom of the internode.

Buds broadly oval, narrowed below, obtuse, glabrous, plump but closely appressed.

Leaf sheaths glabrate; shoulders narrow; throat subglabrous, the vestiture reduced to a few short hairs on the shoulders, ligule abruptly widened at the center.

Leaves numerous, hanging long on the stalk, declined, narrow, long accuminate, minutely serrulated to the base.

B–109.

Habit erect to inclined. Stalks medium to large diameter, yellowish green, not reddening.

Internodes medium length, cylindrical, straight or very slightly staggered; furrow very slight or none.

Nodes medium size, not constricted, limiting ring prominent; root band slightly enlarged; rudimentary roots in 2 to 3 rows; leaf scar glabrate; glaucous band well marked but not constricted.

Buds variable, short, triangular; margin narrow, uniform.

Leaf sheaths glabrate; shoulders narrow, often long pointed; throat with vestiture of coarse hairs; ligule medium to short, entire.

Leaves abundant, medium broad, dark green.

P. R.–202.

Habit erect or the base reclined, very vigorous. Stalks heavy, thick, green, conspicuously glaucous.

Internodes long, large diameter, cylindrical, straight, not staggered, furrow none or very slight.

Nodes scarcely constricted; root band medium width; rudimentary roots inconspicuous, in 2 or 3 rows; limiting ring broad and conspicuous, yellowish brown, slightly elevated; leaf scar glabrous, narrow appressed behind; glaucous band medium width, not conspicuous, blending with the bloom of the internode.

Buds large, hemispheric, the point appressed, prominent but not developing, margin narrow, base and apex appressed, cilliate.

Sheathes glabrate, glaucous, at first with sparing white vestiture, which is soon deciduous; shoulders broad, usually not lobed, throat narrowly lannate, vestiture short and scanty; ligule short, margin nearly even; collar narrow, not reaching midrib, brown, minutely lannate.

Leaves erect except the extreme tip, rather short, broad, inrolled, minutely serrulate almost to base, the serrations ending in hair like awns below.

G. C.–493.

Habit declined, vigorous. Stalks heavy, yellowish green.

Internodes long, cylindrical, straight; furrow none or scarcely evident.

Nodes broad, not constricted; root band broad; rudimentary roots brownish, in about 3 rows; limiting ring broad, elevated; leaf scar glabrous, not prominent, appressed behind; glaucous band broad but poorly defined.

Buds subhemispheric, reddish, margins broad, equal, base, margin and apex cilliate.

Leaf sheaths glabrate; throat minutely lannate, vestiture reduced to a few short hairs; shoulders with short lobes; ligule narrow, even; collar minutely lannate.

Leaves declined, narrow, minutely serrulate above, even below.

P. R.–317.

Habit subdeclined, vigorous Stalks numerous, light green, not glaucous.

Internodes long, cylindrical, somewhat staggered; furrow slight or none.

Nodes prominent, oblique, scarcely constricted; root band rather broad; rudimentary roots white, in about 4 rows; limiting ring obscure but somewhat elevated; leaf scar glabrous, heavy and prominent below the bud appressed behind; glaucous band conspicuous.

Buds ovate to narrowly ovate, flat, appressed; margin narrow, uniform, glabrous.

Leaf sheaths with dense vestiture; shoulders equal or sometimes one with small lobe; throat lannate and with medium vestiture of longer hairs; ligule prominent, broadest in the middle, even; collar conspicuous.

Leaves with the tips declined, medium width and color, minutely serrulate above, even below.

P. R.-219.

Habit often declined at base, medium vigor. Stalks of medium diameter, green, not conspicuously glaucous.

Internodes rather short, cylindrical, not staggered; furrow none.

Nodes slightly constricted above; root band medium width; rudimentary roots inconspicuous, whitish, in about 3 rows, often developing under the leaf sheaths; limiting ring inconspicuous, greenish; glaucous band poorly defined.

Buds medium to small, broadly oval, obtuse, rather prominent but the point appressed, not developing; margin narrow, uniform; base and apex cilliate.

Leaf sheaths with heavy vestiture of stiff hairs at length partly deciduous, somewhat glaucous; shoulders rather broad, usually not lobed; throat with heavy vestiture; ligule medium width, nearly even; collar narrow, reaching the midrib, minutely lannate.

Leaves erect except the tips, rather narrow, medium to short, often inrolled and subplicate, serrulate almost to base.

P. R.-260.

Habit erect, vigorous. Stalk green with heavy bloom.

Internodes rather long, cylindrical, straight or slightly staggered, furrow shallow but well marked.

Nodes scarcely constricted; root band and rudimentary roots indistinct; limiting ring elevated; leaf scar prominent, narrower behind but not appressed; glaucous band obscured by heavy glaucous coating of the internode.

Buds long, narrowly ovate or sublanciolate, with a long acute point, soon developing and becoming prominent, bearded at the base and apex.

Leaf sheath with heavy vestiture; shoulders with long pointed lobe; vestiture of throat abundant but not reaching the midrib, lannate.

Leaves erect, the tips slightly declined, medium width, closely and finely serrulate throughout but less so below.

Otaheite.

Habit erect, often becoming declined. Stalk greenish yellow.

Internodes medium to long, often tumid, sometimes flattened, somewhat staggered; furrow medium.

Nodes medium, longest at bud side; root band not constricted; rudimentary roots in 2 or 3 rows; leaf scar glabrous, oblique, promiment below the bud; glaucous band constricted, well marked.

Buds sub-elliptic to ovate; margin narrow, uniform; sides and apex bearded.

Leaf sheaths with heavy vestiture; shoulders large, often acutely lobed; throat with moderate vestiture of soft hairs mostly on the shoulders; ligule medium length, retuse.

Leaves erect except the tip, medium width, long accuminate.

D–625.

Habit erect Stalks long and large, light green to yellow.

Internodes long, cylindrical, often somewhat staggered; furrow broad but shallow.

Nodes long and prominent; limiting ring broad, elevated, reddish brown; root band broad, as large or larger in diameter than the internode; rudimentary roots distinct, in 2 to 3 rows; leaf scar glabrate; glaucous band shallow, but little constricted.

Buds large, uniform, triangular, plump; margin narrow, uniform; apex and sides bearded.

Leaf sheaths with abundant vestiture of soft setæ; shoulders small; throat lannate and with vestiture of fine hairs on shoulders and behind ligule; ligule medium length; rounded.

Leaves suberect, medium green, tapering abruptly to a fine point.

B–6450.

Habit reclining. Stalks medium length and diameter, green, yellowing on maturity but with no reddish tints, often minutely checked when mature, somewhat glaucous.

Internodes medium length, somewhat tumid, more or less staggered, furrow broad but shallow.

Nodes medium length, constricted; root band rather broad; rudimentary roots white, distinct, in 2 to 4 rows; leaf scar glabrate; glaucous band strongly constricted.

Buds medium size triangular-ovate, flat, margin narrow, uniform, hirsute at base.

Leaf sheaths with rather fine, soft vestiture; shoulders broad, often pointed; throat with soft vestiture; ligule medium.

Leaves abundant, medium green, tips declined.

P. R.–208.

Habit semi-erect, vigorous. Stalks stout, green.

Internodes of medium length, nearly cylindrical but enlarged below on side of bud, somewhat staggered; furrow well marked.

Nodes constricted; root band constricted; rudimentary roots in about 3 rows; limiting ring narrow, sunken; leaf scar glabrous, appressed behind; glaucous band constricted, well marked.

Buds broadly oval or subtriangular, appressed, margin broadest in middle but scarcely shouldered, the apex cilliate.

Leaf sheaths with heavy vestiture; shoulders narrow; throat with

abundant vestiture reaching the midrib, also appressed lannate; collar glaucous, brown, conspicuous, reaching the midrib.

Leaves broad, suberect, the tips declined, minutely serrulate, the serrations ending in weak, appressed tips that become longer and hair-like below.

B-1809.

Habit erect. Canes long, large, green, becoming yellowish.

Internodes long, flattened, usually largest below; furrow broad and rather deep.

Nodes large, conspicuous; limiting ring broad and prominent; root band prominent, enlarged above to meet the prominent limiting ring; rudimentary roots in 2 to 3 rows; leaf scar glabrate; glaucous band somewhat constricted.

Buds large, triangular but longer than broad, pointed; margin narrow, uniform or with small marginal lobes, bearded.

Leaf sheaths glaucous and with medium stiff vestiture; shoulders small; ligule medium length, the center depressed: throat with medium vestiture.

Leaves abundant, erect, medium green, rather broad.

D-117.

Habit erect. Stalks long, medium diameter, light green to yellowish green.

Internodes medium to long, slightly flattened, swollen at base on the bud side, straight behind; furrow shallow but broad.

Nodes large, somewhat oblique; limiting ring prominent; root band broadest on side of bud; rudimentary roots crowded in 3 or 4 rows; leaf scar glabrate prominent below the bud, appressed behind; glaucous band medium.

Buds broadly ovate or triangular, acute; margin medium to narrow, uniform, not shouldered; apex and sides barbellate, sometimes expanding but not prominent.

Leaf sheaths with sparing vestiture of soft setæ; shoulders often pointed; throat lannate, and with long hairs on the shoulders; ligule short, rounded or center depressed.

Leaves spreading, the tips declined, medium green, medium length and width.

P. R.-210.

Habit erect, strict, vigorous. Stalks dark green.

Internodes medium to short, cylindrical, no furrow, a zone conspicuously discolored by minute checks or cracks below the node.

Nodes prominent, often oblique; root band narrow, clearly marked; rudimentary roots in about 3 rows; leaf scar glabrous, short, appressed behind; glaucous band clearly marked.

Buds prominent, sub-hemispheric, tinted reddish brown, the point soon developing; margin broadly lobed; sides and tip appressed, ciliate.

Leaf sheaths with moderate vestiture below, subglaucous above; shoulders usually with one long-pointed glabrous lobe; throat with short scanty vestiture; ligule narrow, even; collar brown, reaching the midrib, glabrous.

Leaves narrow, dark green, strictly erect, accuminate; margin sparingly serrulate above with short, hooked teeth, even toward the base.

P. R.–308.

Habit erect. Stalk stout, green, not glaucous.

Internodes short, stout, enlarged below, staggered; furrow shallow.

Nodes broad, rather prominent; root band swollen; rudimentary roots large but not conspicuous, in about 3 rows; limiting ring broad, conspicuously elevated; leaf scar glabrous, medium width, equal on all sides; glaucous band conspicuous, somewhat constricted.

Buds small, subhemispheric, margin narrow but shouldered, giving obovate effect, glabrous.

Leaf sheaths with moderate vestiture of long soft hairs; shoulders narrow, usually not lobed; throat with very scanty vestiture, almost glabrate; ligule very narrow, entire; collar narrow but reaching the midrib, dark brown, lannate.

Leaves erect with tips declined, very broad, abundant, sharply serrulate to the base.

B–208.

Habit erect, then inclined. Stalks medium length, large diameter, green, somewhat glaucous, no tints of red.

Internodes short, tumid; furrow very shallow.

Nodes small, constricted; root band slightly constricted; rudimentary roots in 2 to 3 rows; leaf scar glabrate; glaucous band narrow, strongly constricted.

Buds large, subhemispheric, soon developed and prominent; margin broadest across the top.

Leaf sheaths with long stiff vestiture; shoulders small; ligule medium length with center slightly depressed; throat with abundant vestiture of soft hairs.

Leaves not abundant, short, rather broad, dark green, tapering to an abrupt point.

BIBLIOGRAPHY OF PAPERS DEALING WITH CANE VARIETIES IN PORTO RICO.

CRAWLEY, J. W.—Annual Report Sugar Producers' Association of Porto Rico 3 (Bull. 5) 13–15, August 1913.

COWGILL, H. G.—Informe del Perito en Plantas de Semillero para 1913–14. Reimpreso del Tercer Informe, 6–10, 1915.

COWGILL, H. G.—Annual Report, 4: 28–29, 1916.

COWGILL, H. G.—Report of the Plant Breeder. Report of the Board of Comm. of Agric. 5: 16–25, 1917.

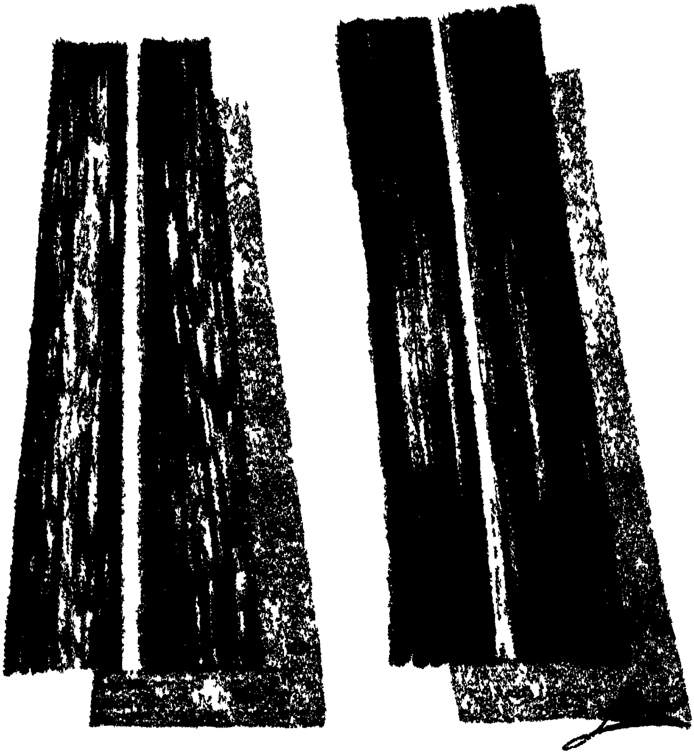
COWGILL, H. G.—Annual Report, Insular Experiemnt Station, July 1, 1916, to June 30, 1917. Report of the Plant Breeder, 15–26, 1917.

COWGILL, H. G.—Distribución de Caña para Semilla. Estación Experimental Insular, Circular No. 8: 10–13, 1917.

COWGILL, H. G.—A Method of Identification and Description of Sugar Cane Varieties, and its Application to Types Grown in Porto Rico. Journal of the Department of Agriculture of Porto Rico, 1: 119–140 (July 1917).

MAY, D. W.—Federal Experiment Station Bull. 9, 1910.

MCCONNIE, R. C.—Nuevas Variedades de Caña de Azúcar. Revista de Agricultura de Puerto Rico, 1: 12–17, 1917.



Secciones de Hojas Matizadas.
Variedad Cristalina

Secctions of Mottled Leaves.
Variety Crystalline.

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THE MOTTLING OR YELLOW STRIPE DISEASE OF SUGAR-CANE

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THE MOTTLING OR YELLOW STRIPE DISEASE OF SUGAR-CANE.

By JOHN A. STEVENSON.

INTRODUCTION.

The epidemic of cane disease which has prevailed in the Island through several seasons has continued with unabated severity. Not only has the disease not shown any decrease in virulence in the districts formerly reported as infected but has spread into new areas, and is here likewise causing heavy losses. It seems certain that the portions of the Island as yet free of infection will, before another has passed, fall prey to the ravages of this disease.

Studies as outlined in a previous report (31)[1] have been continued as vigorously as circumstances permitted, and it is felt that satisfactory progress has been made toward an understanding of the problems involved. It has been necessary to still further alter views previously held as to the nature of the disease involved. As a result of experimental and field data obtained it has become quite clear that mottling cannot be considered as a form of degeneration and that it is an infectious disease.

A complete discussion of all phases of the problem, covering the work of practically three seasons, follows in the body of this paper, and will form a final report by the writer on the mottling disease of cane.

[1] Figures in parenthesis refer to literature cited on p. 66.

NOTE.—Credit is due Mr. E. D. Colón, now Director of the Insular Experiment Station of the Department of Agriculture of Porto Rico; to Mr. R. C. Rose, formerly first assistant pathologist, and to Mr. Bernardo López, assistant, division of plant pathology and botany for assistance in the work of obtaining field data and other information. Favors extended by officials of the South Porto Rico Sugar Co. have aided in the prosecution of the work.

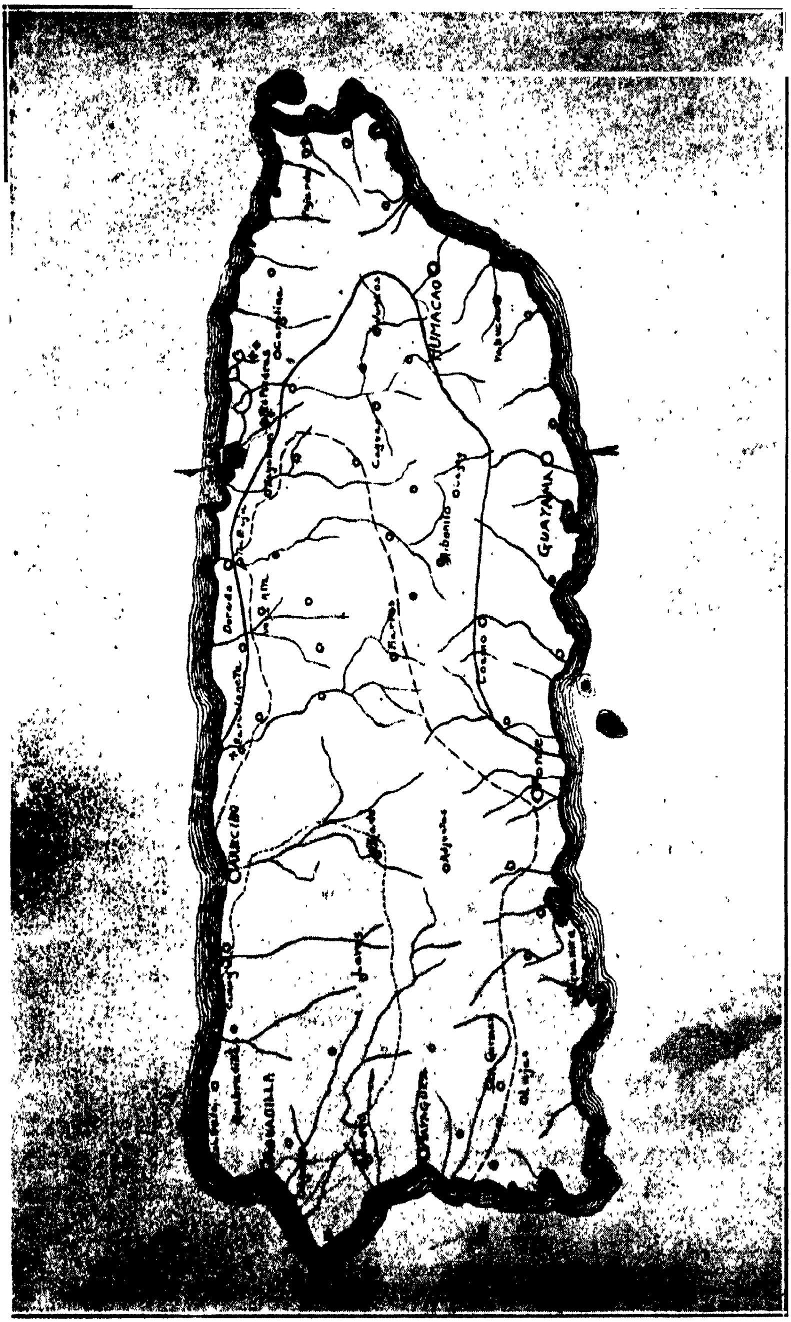

FIG. 1.—Sketch-map of Porto Rico, showing successive diseased areas.

NAME OF THE DISEASE.

Various names have been applied to this malady. It is universally known among the planters as *la enfermedad* (the disease) all other cane diseases of their experience sinking into insignificance in comparison with it. Of late it has also been called in popular accounts *mordida de perro*. The writer has referred to it at various times as the "new disease, the mottling disease, and cane canker," but considers the term mottling disease more nearly descriptive than any other, and therefore preferable. This name was definitely proposed in the 1916–17 report.

Cane canker is not considered suitable since the canker stage is not always present. Chlorosis, which might be used, and in fact was used to some extent, is pre-empted by a very different type of non-parasitic disease occurring in limited areas on the south coast. Prof. Earle (9) has recently used the term mosaic [1] which has nothing to recommend it in preference to mottling. Mr. Colón in the same paper refers to the disease as yellow-striping or *enfermedad de las rayas amarillas*. This is hardly suitable since it is not descriptive of the disease on the one hand and on the other will cause confusion with the natural phenomenon of yellow striping so common in certain varieties of cane, particularly the dark red, and which is a non-parasitic phenomenon of the class referred to by plant breeders as chimeras.

DISTRIBUTION.

The disease has made very definite and rapid progress during the time it has been under observation. At the end of the first season's studies as noted in the 1915–16 report (26), it had attacked the cane in the region bounded by Aguadilla to the west and a line from Utuado to Arecibo, or along the valley of the Arecibo River, on the east. Lack of time did not then permit the working out of more exact boundaries, particularly along the south and west.

The approximate extent of territory covered by the disease up to July 1, 1916, is shown by the dotted line on the map (Fig. 1). The area already covered at this time indicates that the disease had been active for some years at least, and it is not impossible that it had been present for a much longer time as a minor trouble in the upland fields beyond the coastal plain. Some planters have declared that the disease has been known to them for many years, and others are equally confident that it is an entirely new proposition. Be-

[1] A name suggested and used by Mr. F. S. Earle, Specialist on Cane Diseases, Insular Experiment Station, because it at once indicates what he believes it to be the nature and relationship of the disease.—EDITOR.

cause of the ease with which the mottling is confused with other cane diseases and abnormalities such as yellow spotting, chlorosis, striping, and others discussed further on in this paper, it is impossible to arrive at any conclusion, based on information obtainable to date, as to when it was first introduced to the Island.

During the remainder of 1916, and throughout the time since then the disease has made continuous and extremely rapid progress. The broken line on the map indicates the area covered up to the date of the last report (31) preceding the present one, as far as data was available.

It will be noted that it had by this time occupied at least half the extent of the Island, having advanced a considerable distance to the east, and reached a point south of San Germán on the west. In commenting on the spread of the disease for the 1916–17 season it was noted "that the trouble has been largely confined to the upper reaches of the river valleys, to small enclosed inland valleys, and practically to fields among the foothills. The broad stretches of the coastal plain, but little above sea level, are still free or comparatively free of disease. Near Arecibo many of the lowland fields show on the average one per cent of mottled stools, but farther east, in the lowlands of the Plazuela Sugar Company,[1] it was impossible to find a single diseased stool, although mottling commenced the instant the foot-hill formation began. This state of affairs was hardly to be expected, if the cause is parasitic, since these lowland fields are planted to susceptible varieties and form great continuous areas, often extending for miles in unbroken stretches."

This state of affairs has continued in large part to date, infection not being uniform and continuous in these lowland tracts. It has been possible in specific cases to trace the source of infection to use of diseased seed rather than to natural agencies where serious amounts of disease have been found.

At the present writing (November, 1918) the disease has covered over three-fourths of the Island as shown by the solid line on the map (Fig. 1). The disease-free area now includes only the cane-growing regions of the coast from San Juan to Fajardo, and those from Fajardo to the south as far as Central Fortuna.[2] To the west of San Juan the coastal area is comparatively free of mottling as far as inspections have been carried, but indications point to a serious outbreak here before another season has passed. Isolated infections

[1] These lowlands are at present infested also.—EDITOR.

[2] Outbreaks of mottling have been reported recently at various places between Central Fortuna, near Ponce and Central Lafayette, near Arroyo, as well as in the Fajardo and Naguabo districts.—EDITOR.

have been located at several points in the eastern sections, from which beyond much doubt the remainder of the territory will be speedily attacked. It is interesting to note that the inland valley districts of Caguas, Juncos, Cayey and Utuado are seriously infected, even though practically isolated. The cane fields around Utuado have been diseased for at least four seasons, but those of the other three districts had been free until within a year. This bears out the statement made in the previous report (31) concerning the manner of progress of the disease.

"In its eastward course the disease has apparently jumped from valley to valley, or has appeared spontaneously at many points some distance back from the ocean, rather than working along through the continuous coastal fields and then up each successive valley. It has almost universally evinced a marked preference for upland fields, in spite of the fact that they do not form the continuous areas so characteristic of the lowland country. Not only are these fields themselves broken up by the numerous small hills, but the many valleys large and small are separated by extensive ridges and chains of hills."

In the original center of the infection area from Arecibo to Aguadilla, the disease has continued severe where cane has been planted, but there was a general movement in this region to abandon cane in favor of tobacco and other minor crops.

The situation at Utuado remains unchanged with fifty to one hundred per cent of infection, and the same conditions prevail in the neighborhood of Adjuntas.

From Aguadilla southward there is probably not a field which will not show from one to fifty per cent of infection. Here again the disease was first noted and first caused serious loss in the uplands but has now spread throughout all fields. In fact reports from the Aguadilla-Aguada district (Central Coloso) were to the effect that there was less disease during the season just past in the uplands than in the lower lying fields. Such field observations as time permitted seemed to verify this conclusion, but it can doubtless be explained by the fact that the upland fields, after being abandoned to the disease the year before, were given thorough cultivation and replanted with selected seed, while the lowland fields were being ratooned.

The cane fields of the entire southwest section of the Island are in what might be termed the second phase of the disease in which a decrease in yield is becoming very apparent. A year ago only very slight infections were noted, less than one per cent in the aggre-

gate, and many fields were entirely free of mottling. During the past season practically every field has become infected to a varying extent, and there is every indication that serious losses will be sustained in the coming crop.

Along the south coast the disease has advanced to the east beyond Ponce as far as Fortuna. It is particularly serious in the neighborhood of Peñuelas to the west of that city, as well as in the cane growing sections immediately adjoining it.

There is every indication that in the coming season the disease will continue to a successful conclusion its conquest of the cane fields of the Island, since only a comparatively small section remains and this already has several known points of infection.

AMOUNT AND NATURE OF THE LOSSES.

It is difficult to arrive with any degree of accuracy at the losses sustained by the cane growers as a result of the ravages of this disease, because of the great variation in amount and severity of infection from field to field. In last year's report an estimate of $500,000 loss for the season was made and this was considered conservative.

A comparison of sugar statistics for two seasons past will give some measure of the loss sustained. The 1917 crop as reported by the Bureau of Property Taxes of the Treasury Department was 503,081 tons of sugar, while that of 1918 fell off to 453,795 tons. This shows a decrease of 49,286 tons with a value of over $5,000,000 figuring sugar at $5.27 per hundredweight, the average price for the season. Not all of this loss, however, can be charged to the mottling since the weather in certain sections and particularly in some where the disease had not penetrated, was such as to cause a heavy falling off in yield. A comparison of the output of the centrals (factories) of the Island for the two years makes it appear that at least half of this disease may be charged to the disease making the loss for 1918 $2,500,000.

Comparable results cannot be obtained by a study of the statistics for earlier years since economic conditions have been such as to cause great variation in the amount of cane planted, independent of natural factors. In the last two seasons, however, the area planted has been practically uniform except as influenced by the disease.

If to the figure $2,500,000, the estimated loss for 1918, there be added $500,000 for 1917, and the same amount for all previous years (but 1916 for the larger part), we reach a total of $3,500,000 loss to the sugar industry of Porto Rico to date.

The loss as heretofore has fallen heaviest on certain north coast mills. Several not before affected have suffered appreciably in the crop just past and there has been no improvement in the output of those which bore the brunt of the attack last year. One case in particular may be mentioned where the production for the year was only half that of the previous season, due without any question to the effects of mottling. Another central reported a loss of nearly eight thousand tons, again entirely chargeable to the same cause. At least ten other sugar companies have a falling off of from five hundred to three thousand tons each which can not be attributed to drought or environmental factors.

Many of the *colonos* (growers who sell their cane to the centrals) and more especially those in the Arecibo-Aguadilla region where the disease first attracted attention, have been forced out of cane growing and have taken up tobacco, or other less remunerative crops. Their number is rapidly increasing. The adjustment necessary to the growing of new crops entails no little loss under present economic conditions with greater liability of failure because of unfamiliarity with cultural conditions.

To turn to the nature of the losses incurred. As will be noted from the discussion under symptoms the losses result primarily from a decrease in tonnage. In the very early stages of infection it is not apparent to the observer that there is any reduction in yield or amount of sugar present in the juice. Exact experiments have not been carried out locally to test this point, but an experiment performed by Lyon (20) of the Hawaiian Sugar Planters' Experiment Station with a disease called by him yellow-striping, which is similar in nature to mottling, gives an exact idea of the reduction in tonnage and sugar content.

"The experiment, planted in eight 80-ft. rows was arranged as follows:

Rows 1 and 8, outside, blanket rows.
Rows 2, 4 and 6 cuttings from healthy canes.
Rows 3, 5 and 7 cuttings from canes having yellow stripe disease.

"Two cuttings of three eyes each were taken from the top of each stick. All of the cuttings were carefully inspected to see that each had three perfect eyes. Sixty cuttings, thirty top and thirty second, were planted in each row, the top and second cuttings being similarly placed in each row.

"The cuttings from sound and diseased canes sprouted equally well and gave what appeared to be a uniform stand of cane. Not

a single stick tasseled in the experiment during the winter of 1912–13, but most of them tasseled in November, 1913.

"The cane was cut during the last week in February, 1914, giving the following results:

"From healthy cuttings, rows 2, 4, and 6—

Healthy canes	430 weighing	3,991.0 lbs.
Diseased canes	81 weighing	693.5 lbs.
Undetermined canes	137 weighing	887.5 lbs.
Total millable canes	648 weighing	5,572.0 lbs.
Dead canes	187 weighing	553.5 lbs.

"From diseased cuttings, rows 3, 5, and 7—

Healthy canes	3 weighing	28.0 lbs.
Diseased canes	335 weighing	2,683.5 lbs.
Undetermined canes	75 weighing	387.5 lbs.
Total millable canes	432 weighing	3,099.0 lbs.
Dead canes	210 weighing	534.5 lbs.

"Juice samples were obtained by grinding the cane from corresponding sections in the centers of two rows. The analyses were as follows:

From healthy canes	Brix 20.3,	sucrose 19.07,	purity 93.9
From diseased canes	Brix 20.1,	sucrose 19.11,	purity 95.1

"The yields per acre computed from the above data would be:

Healthy canes	101.13 tons cane,	14.98 tons sugar.
Diseased canes	56.24 tons cane,	8.43 tons sugar.
Difference	44.89 tons cane,	6.55 tons sugar.

"When comparing these yields it should be noted that twelve per cent of the canes from healthy cuttings became diseased during their growth so that the yield from healthy cuttings was thereby somewhat reduced."

As the disease progresses and during the second year of its presence as a general rule, there is a very marked falling off in the yield, which may vary anywhere from twenty to one hundred per cent. From this stage on there is also an accompanying decrease in the amount of juice in the canes. The final stage in which no merchantable cane is produced and the field is abandoned may occur the second year, but more commonly during the third, or on the second ratoon. Hundreds of acres have reached this stage and thousands more are approaching it.

In the severely diseased stalks of this latter stage (those showing cankering and splitting) there is not only the reduction in size and

the dry pithy condition due to a lack of juice, but what juice is present is highly objectionable from the viewpoint of the mill. Several mills have reported a high and therefore undesirable glucose ratio with correspondingly low sucrose, but other tests have not substantiated this. The length of time between cutting and milling may well account for this in the instances reported, due to the cracked, cankered condition of the canes, which exposed the sugar containing tissues to the action of the air and fermenting organisms.

Some further data along this line will be found under the heading "Chemical tests of the juice."

RATE AND MANNER OF SPREAD.

The rate of spread in general as applied to the entire Island has already been given. To obtain a more detailed idea of the rate and manner of spread careful notes were kept on the progress of the disease in several fields near Río Piedras. As this was an isolated infection area, no other diseased cane having been found within at least ten miles until very recently, the data obtained illustrates the manner of spread from a single infection.

About 1915 a small planting (several rows) of Penang cane, the seed for which had been brought from near Aguadilla, was made as part of a variety experiment. The experiment after two seasons was transferred to another field with the exception of the Penang, which had practically died out. This condition had not been called to the writer's attention and it cannot be definitely stated that mottling was the cause of the trouble, although all evidence points to that conclusion. The field was not examined until after it had been plowed but several volunteer cane shoots, well marked with the disease, found some weeks later confirmed this opinion. Field men after having been shown characteristic specimens agreed that the disease had been present on the variety in question.

In the second field mottling was not noted until several months after planting, when infected stalks of B–3922 were found. As this variety had adjoined the Penang in the first test it seemed reasonable that a transfer had taken place at that point and that diseased seed had subsequently been planted in the second field. Infected stools were marked as they were found and their behavior during the season watched, stool to stool search being made at intervals. It was particularly desired to ascertain the age at which cane was susceptible to attack as well as the rapidity with which it spread from stool to stool.

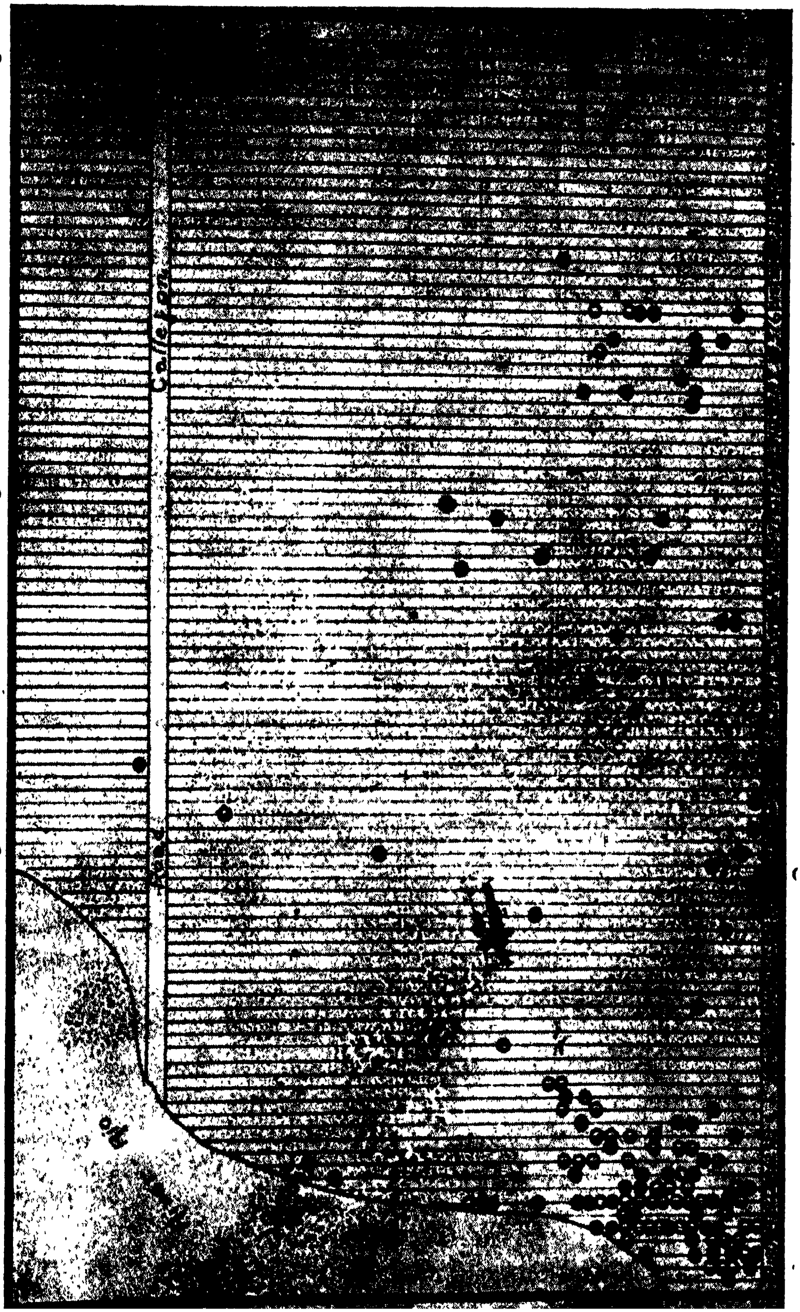

FIG. 2.—Sketch-map of experimental field, illustrating manner and rate of spread of disease.

The following table gives the number of diseased stalks found in each stool throughout the season:

Table I.—Occurrence of Diseased Stalks.

Stool No	DATE OF OBSERVATION						
	May 16	June 11	June 23	July 10	July 30	August 17	Sept 20
1	3	3	3	3		4	4
2	7	8	8	8	6	5	4
3	12	12	13	13	13	10	10
4	1	1	1	1	1	1	1
5	2		3	[illegible]	3	[illegible]	3
6	2	3		2	[illegible]	2	2
7		1	1	[illegible]	[illegible]	3	3
8		1	12	11	10	8	8
9	[illegible]		1			3	3
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	2
11	[illegible]	[illegible]	1	[illegible]	2	2	2
12		1	10	6	[illegible]	6	6
13	5	6	7	[illegible]	6	6	6
14	1	1	1	1	1	1	1
15	10	11	11	7	7	[illegible]	5
16		6	6	4	4	4	3
17		[illegible]	[illegible]		4	4	4
18					1	1	1
19					3	4	5

It will be noted that there was comparatively little change, a number of weaker suppressed stalks dying, and a few additional ones developing the characteristic symptoms. As near as could be ascertained the mottled shoots in each stool arose from seedpieces other than those producing the normal shoots which predominated in nearly all the stools. Four seed pieces were planted in each hole, their combined stalks making up the stool.

Several other stools in adjoining varieties showed mottling during the season as noted on the chart. (Fig. 2.) The results obtained here, combined with a series of field observations, make it evident that the bulk of infection occurs in young plants.

At the end of the season all diseased stalks (none had shown cankering or other abnormalities beyond the leaf signs) were cut and destroyed. When the first ratoon shoots had reached approximately a foot in height, an attempt was made to eradicate the disease from the field, sufficient evidence having been obtained by that time of the ability of the disease to spread by other means than infected seed pieces. Six times during the season the entire field was gone over and all mottled canes dug out and destroyed. The first time over the field only stalks actually showing signs of the disease were removed with the corresponding rhizome and root portions. In every case, however, the disease reappeared in these stools necessitating further removal. This indicates that where eradication work

is attempted the entire stool must be removed even though but a portion of the stalks composing it show actual signs of mottling.

Wherever possible the stools were dug out carefully and search made for mottled and normal appearing shoots on the same rhizome. About twenty such cases were found in the course of the season and in each case a planting was made in the plant house of a portion of the apparently normal stalk. All of these, at a time varying from germination to several months later, produced leaves with the characteristic markings. It was very clear that once infection occurred the virus or infecting principle spread through all parts of the plant, even though it might not be apparent in all the stalks.

This eradication experiment will be further discussed under control measures.

OCCURRENCE OF THE DISEASE IN SANTO DOMINGO AND ELSEWHERE.

The presence of very pronounced mottling on recently germinated Crystallina cane, the seed for which had been imported from Santo Domingo, made it evident that the disease also occurred in that island. In order to investigate the nature of its behavior there, and with the hope of obtaining other information of value, this island was visited in the course of the year. The results of this trip as given in a report prepared at the time are as follows in so far as they apply to the mottling:

"The first case (mottling) was found in the fields in the vicinity of Higueral, north of La Romana. The disease was present in practically all fields varying in amount from a few scattered stools to as high as thirty per cent. The variety of cane was Crystallina. Symptoms of the disease, while characteristic, were limited to the mottling of the leaves. No evidences were seen of any stalks bearing the canker stage, in which the disease has proven so destructive in Porto Rico. Taken as a whole the cane in this district (Central Romana) appeared to be in fine condition, the presence of mottling having no appreciable effect on its growth.

"The disease was again encountered at Samaná in small plantings, the seed for which had been brought from San Pedro de Macorís in the year previous. This latter fact makes it quite evident that the disease also exists in the extensive plantings at Macorís although no opportunity was had for a personal examination at that place.

"Only very small plots of cane were found at San Francisco de Macorís and these were free of the disease. Similarly at Cabu-

llas, a point between San Francisco de Macorís and La Vega on the railroad, the cane was normal.

"Small plantings in the vicinity of La Vega were on the other hand typically diseased. No cane was seen in the Santiago section It was not found feasible to visit the cane growing districts around Puerto Plata.

"In the neighborhood of Monte Cristi several small plots of cane were found, as well as one field of considerable size, which furnished cane for a small sugar and molasses mill. The cane in the latter field was heavily infected, as high as twenty per cent of the stools showing the typical markings on the leaves. As in the other instances no stalk cankers were seen or evidence of appreciable stunting of affected stools. Other cane plantings in this section were also affected, the seed having been brought in large part from the above mentioned field. One small patch was over fifty per cent infected. The cane was a mixture of the Rayada or striped and a white type, probably the Otaheite or Bourbon.

"These two varieties were also seen in the small plots examined in the Republic of Haiti between Dajabón, Santo Domingo, and Cap Haitian. They were, however, free of the mottling in so far as noted.

"On the return trip to the capital very characteristic examples of the disease were found in small patches of cane around dwellings at Bonao and along the trail in and out of the same *pueblo*.

"With the exception of the fields at La Romana no extensive plantings were seen on the trip until the capital was reached. East of Santo Domingo City there are two centrals, each with a large acreage of cane. Examinations were made here and the disease found in abundance and very typical in appearance! Small plots of cane to the westward of the city along the San Cristóbal road were unaffected.

"It thus appears that the mottling disease is widespread in Santo Domingo, occurring not only in the large commercial holdings but to a large extent throughout small scattered native patches. It seems reasonably certain that the disease has been present for many years, although there may have been recent reintroductions through some of the southern ports. The most interesting feature observed is the fact that while the leaf form of the disease—that is to say, the mottling—occurs very characteristically, it was not possible to find a single specimen showing the cankering and drying of the stalks.

"One can but conjecture as to the why of this state of affairs,

possibly the cane through generations of contact with the disease has reached a certain stage of immunity or Porto Rico has fallen heir to a more virulent strain. A more probable explanation lies in the practically virgin soils of Santo Domingo which tend to produce vigorous, more resistant canes. It is at least clear that Porto Rico need have no fear of further cane introductions from the neighboring island and on the other hand it may be found advisable to bring over the apparently resistant canes for further trial here.

"As far as the cane growers of Santo Domingo are concerned it does not at present appear that they need fear the mottling, but it would be well for them to become familiar with the disease and its latent possibilities for serious damage. Seed selection should be vigorously carried out to reduce the mottling to a minimum and any variety showing great susceptibility should be discarded."

One area of infection has been found on the Island of St. Croix, American Virgin Islands, by Dr. Longfield Smith, director of the experiment station. This case was very definitely known to be due to infected seed imported from Porto Rico. Prompt measures were taken to eradicate all diseased cane and it is hoped that there will be no spread of infection.

Correspondence [1] has failed to elicit further definite information as to occurrence. It seems probable at this writing that the disease is not present in any of the British West Indies, but that it is present in Cuba in much the same manner as it is in Santo Domingo. The relation of mottling with the yellow stripe disease of Java and Hawaii, and the distribution of the latter is discussed elsewhere in this paper.

VARIETIES ATTACKED.[1]

The list of varieties attacked is nearly as long as that of the varieties known to the Island. When the first investigations of mottling were made one variety was found subject to attack almost to the exclusion of all others. This was the common white cane (Otaheite or Bourbon) locally known as *Blanca*. It was this fact in large part which led to the conclusions given (26) in the first report on the situation. Very soon, however, the striped or *Rayada*

[1] Since the above was written information has been received from Mr. George L. Fawcett, plant pathologist of the Estación Experimental Agrícola, Tucuman, Argentine, to the effect that a disease occurs in the cane of that country which he believes to be similar to the mottling. From specimens and a photograph sent by him to the writer it has been possible to confirm his diagnosis. According to Mr. Fawcett the Argentine disease was formerly very prevalent on much grown varieties which have been replaced by others which are resistant to it, hence the disease is not causing appreciable loss at present. It is altogether probable that the importation of one or more of the varieties grown there will solve the problem for Porto Rico.

[1] See Bulletin 19—Insular Experiment Station (May 1919) "The Resistance of Cane Varieties to Yellow Stripe or the Mosaic Disease."—by F. S. Earle.—EDITOR.

fell prey and by the second season was no more resistant than the *Blanca* and has continued so since that time.

A third type grown at that time in the Arecibo district was a dark red hard variety, the so-called *Rayada morada* or *Sarangola,* which was introduced several decades ago to replace less resistant types during an epidemic or disease or insect visitation. During the first season it was markedly resistant, not a single authentic case of disease having been found upon it. Since then it has succumbed and while not so severely affected as the white and other varieties, the fact that it is susceptible combined with its poor milling qualities, make it an undesirable cane, and its use is no longer recommended.

A variety known as Penang grown to a limited extent in the vicinity of Aguadilla and said to have been introduced at the same time as the *Sarangola* has been practically exterminated, and may well have been the means of introducing the disease to the Island, since it is thought to have come from the eastern tropics. There is, however, no direct evidence to support this hypothesis. Further mention of the Penang is made under the discussion of an experiment in the rate and manner of spread of the disease.

Crystallina is the most extensively grown cane in the south and eastern sections of the Island, so that it is only recently that its resistance to the disease has come to a test. Unfortunately, because of its excellence as a commercial variety, it appears only too certain that it will prove no better than the other standard varieties. Seed of this variety was brought into the Arecibo region at considerable expense from what was at the time a disease-free area and planted in comparison with the *Rayada.* The plant crop (1919 season) exhibited enough mottled stools to make it evident that little hope could be had of its proving strongly resistant. As was noted this variety has been found infected in Santo Domingo and such is also the case to a very large extent in the newly infected areas of the south coast. Seed of this variety brought from Santo Domingo and planted near Río Piedras produced approximately ten per cent of mottled shoots upon germination.

Of the many foreign seedling varieties (for the most part those of Barbados and Demerara) experimented with by the division of agronomy of this station, all have shown infection but to a varying degree. Certain ones, as might be expected, have proven most susceptible in all localities, others appear to be fairly resistant as yet, while others vary considerably from one locality to another in their reaction to infection.

B-3922 upon which extensive observations have been made, has been most severely attacked in all places where tried. This has been the case not only on the well watered north coast soils, but under the drier south coast conditions as well. Further notes on this variety are given under another heading.

Yellow Caledonia has shown considerable variation in its susceptibility, certain fields very severely attacked having been seen and in contrast others nearly free have been inspected. This state of affairs, however is possibly to be explained by the presence or absence of the disease in the locality where the cane was under trial.

B-208 has with the exception of the *Blanca* suffered most severely of any of the kinds under observation, and it has been noted in this condition at Camuy, Aguada, Arecibo, and Río Piedras. B-3412 has likewise proven very susceptible when tried in the disease areas. D-117 has stood up as well as any of the better known seedlings, although cases have been reported where it had been nearly one hundred per cent diseased.

Other varieties found infected in varying degree have been B-109, B-4596 (very slight), B-3405, Sealey Seedling, B-6292, B-376, B-1809, D-109, B-6450, B-347, Egyptian 6VI6, 7VII7, and Javan seedlings Nos. 228, 234, and 856. A number of other Javan seedlings are known to be infected, but the numbers are not at hand. As far as known none of these canes as far as tried in Porto Rico have proven immune or even satisfactorily resistant.

Work with native seedlings, carried on by the two experiment stations and two of the larger sugar companies, has hardly progressed far enough to give any conclusive tests. All of the Mayagüez Federal Station seedlings seen (numbers one to five, were badly diseased wherever planted. Of the Guánica seedlings several have been seen diseased and a number of others are reported to be susceptible. From this same source there is also the report of seedlings, only a few months from seed (true seed, not seed pieces), showing typical symptoms.

Seedling work has been carried on most extensively at the Río Piedras station, the first plants having been started in 1912. Of the 1912 seedlings, which were the only ones ready for plantation tests, a number were sent to Arecibo and Aguadilla for trial. Practically all of these have shown slight infection as noted in the tables to follow. Some of them have also contracted the disease recently at Río Piedras.

Two additional varieties may be mentioned as being susceptible, the bamboo or *Bambú* a cane grown to some extent in the Arecibo

valley, which has followed the white (*Blanca*) in its lack of resistance and the Cavengerie, a dark red or wine colored cane, which ranks about with the *Rayada* in its behavior.

Variety tests were inaugurated by the station at a number of points in the disease-infected area in the hope of finding one or more types that would give satisfactory results in the presence of the disease. The results of these from the standpoint of tonnage and other agronomic factors have been reported by the plant breeder (8). Notes were taken on the percentage of diseased shoots showing in the various test plots as a measure of the susceptibility of the varieties involved. In some cases only one count was found possible during the season, but the data, though very incomplete, is given for what it may reveal concerning varietal resistance. In all of these experiments selected seed of the various varieties was sent out from disease-free plots at the experiment station. For the check plots the *Rayada* or striped variety was used, seed being obtained locally in each case. Most of it came from fields showing varying amounts of mottling but an effort was made to have healthy canes only cut for the purposes of the several experiments.

In the first experiment conducted near Aguada one-twentieth-acre plots were used the seedling types being alternated with the native *Rayada*. Only one count was made at the time the cane was about a foot high. The figures following indicate the number of mottled stools counted. Poor germination in half of the field will account for the small numbers in the latter portion of the table. Most of the varieties used were planted in triplicate.

Rayada	29	Rayada	12	Rayada	2
B-1809	20	B-1809	3	B-1809	7
Rayada	20	Rayada	14	Rayada	9
B-376	26	B-376	9	B-376	4
Rayada	19	Rayada	19	Rayada	4
B-6292	13	B-6292	11	B-6292	6
Rayada	20	Rayada	3	Rayada	2
S. Seed.[1]	38	S. Seed.	9	S. Seed.	7
Rayada	32	Rayada	10	Rayada	16
B-3405	6	B-3405	3	B-3405	6
Rayada	19	Rayada	2	Rayada	16
B-6450	7	B-6450	6	B-6450	1
Rayada	19	Rayada	5	Rayada	8
D-117	18	D-117	7	D-117	7
Rayada	17	Rayada	4	Rayada	9
D-109	0	D-109	5	D-109	1

[1] Sealey Seedling.

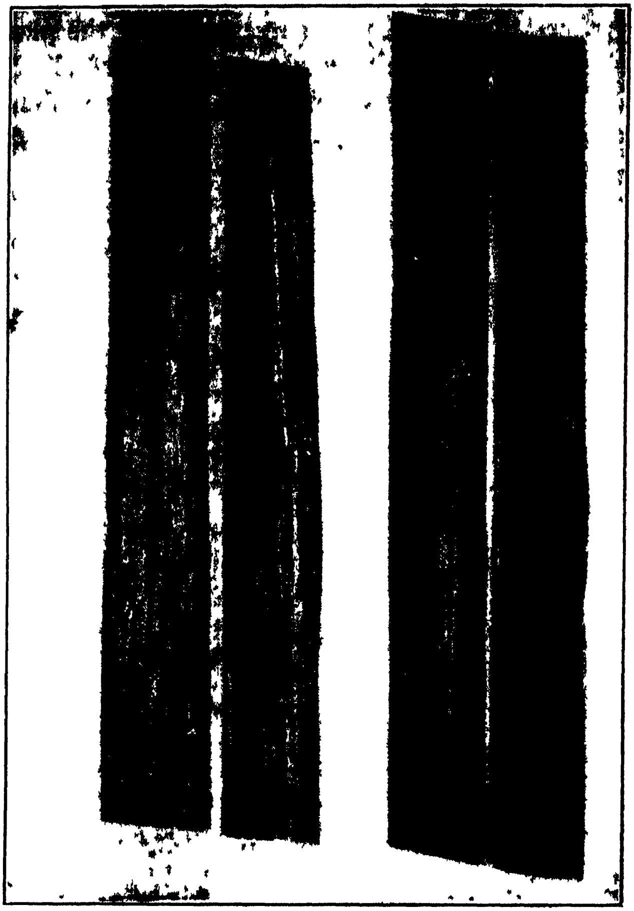

FIG. 3.—Leaf sections; normal at the right, mottled at the left.

Bases de Hojas Enfermas
Variedad Cristalina

Bases of Diseased Leaves.
Variety Crystalline

Rayada	9	Rayada	12	P. R.-292	0
P. R.-208	2	P. R.-260	1	Rayada	5
Rayada	3	Rayada	12	Y. Caled.[2]	2
P. R.-210	4	P. R.-272	2		

These figures give some indication of the relative behavior of the various varieties employed with respect to mottling since all were equally exposed to infection from the surrounding badly diseased fields. It would of course require further counts through the season and especially of the ratoons to be at all certain of the results.

Another plot in the same neighborhood planted the year before as a fertilizer experiment was also examined with the following results. These were tenth-acre plots.

Rayada	91 mottled stools.
D-109	20 mottled stools.
B-3412	99 mottled stools.
D-117	117 mottled stools.
B-4596	7 mottled stools. (4 doubtful).
B-109	58 mottled stools.
Rayada	112 mottled stools.

This more nearly indicates the comparative resistance of certain well-known varieties. Two which have been considered very valuable kinds and recommended for large scale planting here prove to be most susceptible, equalling or surpassing the *Rayada* used in check plots. These figures represent fifty to sixty per cent infections. The most promising canes were D-109 and B-4596 which have also given promise in other tests. It is of interest to note that B-4596 is a variety eliminated from the experiment station tests several years ago because of its great susceptibility to *Cytospora sacchari,* an imported disease which causes a stalk rot. This disease was not present on the cane in the experiment under discussion.

Near Vega Alta a variety experiment was gone over once early in the season with the following notes resulting. As usual, surrounding fields were diseased, in this instance between two and three per cent.

Rayada	9	Rayada	7
B-3405	3	Yellow Caledonia	0
B-109	3	B-4596	3
Rayada	19	Rayada	11
B-6450	1	B-6292	5
Crystallina	5		

An extensive test of varieties was put in in the Arecibo valley

[2] Yellow Caledonia.

again employing selected *Rayada* for the checks, the seed being secured from adjoining fields. Two counts at several months interval were possible here. The figures given indicate the number of stools showing one or more mottled stalks. The plots in this experiment averaged two hundred and ten stools each so that some idea may be gained of the rapidity with which the disease can infect from adjoining fields.

Variety	First examination	Second examination	Variety	First examination	Second examination
B-109	5	4	Rayada	16	18
B-4596	0	0	D-117	7	12
Rayada	3	8	D-109	2	3
B-3405	0	1	Rayada	27	29
S Seed [1]	0	2	B-1809	6	7
Rayada	2	12	B-376	2	5
B-6292	2	6	Rayada	19	24
B-376	2	3	B-6292	7	8
Rayada	16	24	S. Seed [1]	1	2
B-1809	0	1	Rayada	3	5
D-109	1	0	B-3405	2	2
Rayada	12	21	B-4596	2	0
D-117	3	3	Rayada	10	14
B-6150	3	2	B-109	1	2
Rayada	14	33	B 6450	0	0
B-109	3	3	Rayada	3	7
B-4596	0	2	D-117	0	2
Rayada	1	9	P. R. 208	1	1
B-3405	3	8	Rayada	1	4
S. Seed [1]	5	7	P. R. 210	1	3
Rayada	7	13	P. R. 260	1	3
B-6292	12	13	Rayada	10	12
B-376	11	15	P. R. 272	4	2
Rayada	6	8	P. R. 292	2	4
B-1809	6	13	Rayada	3	3
B-6150	0	3	P. R. 317	0	0
....	....	....	P. R. 318	0	2

[1] Sealey Seedling.

NOTE.—Several cases in which there was a reducción in number on the second count are due to the dying of the stools or shoots from diseased seed pieces in the interim.

B-4596 again gives considerable promise of being satisfactorily resistant as do several of the Porto Rico seedlings.

SYMPTOMS.[1]

The one marked and constant symptom of this disease, and the one by which it is easily recognized by any one who has occasion to visit diseased fields is the peculiar mottling of the leaves. It is readily distinguishable from any spotting or striping or other abnormality of cane leaves known to the writer. No trouble has ever been had in definitely ascertaining whether or not the disease was present except in a very few cases, where in new areas or new fields a part of a leaf or a few leaves only were found abnormal. A detailed comparison of the symptoms of mottling with those of other diseases with which it might be confused, is given further on.

[1] Adapted in large part from the 1916–17 report.

In fully expanded mottled leaves of the type commonly found, the backgrounds are green to yellow-green, depending upon the severity of the case. Two rather distinct types of discoloration have been noted but always grading into one another so that it is not considered that they are other than phases of the same phenomenon. Of these one is more common in early stages or light cases and has been especially noted in the unfolding leaves at the top of a stalk, sometimes changing to the second after a time. In this type the background or larger portion of the leaf-blade is a light, abnormal yellow-green and scattered about in it are areas of apparently normal color, "green islands," as it were. These spots are for the most part linear, but will vary from mere points to irregular blotches several centimeters long by a centimeter wide, always with a decided tendency to greater length than breadth. This phase is much more apt to be confused with certain other phenomena than the second, especially where the disease is making its first appearance in a new area.

The most usual phase of this disease seen, the one occurring over thousands of acres and in all varieties) is that in which the leaves are marked with numerous very light yellow-green to nearly white spots and short stripes. The background will vary in color from a normal green in plants but recently attacked to a yellow-green in more severe cases. The markings which produce the mottled effect are always much lighter in color, giving a very decided contrast. They are irregular in shape varying from almost invisible points to irregular spots two centimeters in their greatest dimension. For the most part they are linear, coalescing irregularly, and with indefinite margins. They will at times constitute fifty to sixty per cent or more of the total leaf surface.

The mid-rib remains to all external appearances normal. The leaf-sheaths present no abnormal signs, except a faint mottling in early stages of growth.

Mottled leaves do not die and fall away from the stalk any sooner than do normal ones, nor on the other hand is there any tendency to remain past the usual period of shedding. Varietal characteristics hold in this particular, irrespective of the presence or absence of mottling. There is no difference in the size of the leaves until the general stunting of the stools sets in in advance stages.

As a general rule the leaves are uniformly mottled, but in beginning cases examples are not uncommon in which a portion of a leaf only is affected. Such instances have been found where a stalk previously apparently normal commences to show mottling. The lower

leaves, anywhere from two to a dozen in number, will be to every appearance normal, then there will occur a leaf showing mottling for a few inches only at the base of the blade, which in turn will be succeeded by several others above affected from a half to two-thirds their length. All above these transtional leaves will be completely mottled. Occasionally one half of a leaf may be affected further than the other. The reverse condition of normal appearing leaves above mottled ones has not been observed. Through the season there may be in this manner a gradual increase in the number of stalks infected or at least in the number showing visible signs.

The disease follows what is approximately a three year course.[1] In the first year of its presence isolated stools only will show discoloration, scattered irregularly over the field and often composing less than one per cent of the total. One to five per cent infected is the common condition found in what is considered the first stage. At this time the only symptoms will be the mottling of the leaves above described. Often the first phase only will be present, or where the second also occurs the background will still be dark green. In a given stool the number of stalks showing mottling may vary from one to all, two or three, however, being a very common number. This in many cases merely means that the shoots from one seed piece only are infected (a number of seed pieces, usually four, are planted in each hole and the shoots from these form the stool). It is easy enough, however, to find shoots from a single seed-piece only part of which are mottled.

At this point in the progress of the disease since no other symptoms than the mottling will be found externally or internally, it is impossible after the leaves are removed to distinguish normal from abnormal cane. The internodes are sometimes somewhat shrunken, but the only sure test is to plant portions of suspected stalks and observe the leaves of the new shoots.

In the second year at the usual rate of procedure a very much larger percentage of infection is present. As far as it has been possible to ascertain, this includes all stools which showed mottling the year before, as well as a varying number of those that had been, when the first crop was cut, apparently normal. At this stage, in addition to the mottling, there may be a dwarfing of the stools and the canker stage may be present, depending somewhat upon the variety and possibly other conditions. The dwarfing may be sufficient to cause a loss in yield of from ten to sixty per cent. There is quite

[1] Other observers do not entertain this opinion as to a three year course.—EDITOR

a decided shrinking of the internodes whether the stools are stunted or not.

The crop in the third year (second ratoon) is practically a total loss at the usual rate of progress.[1] This is due to the combined effect of dwarfed stools producing very short lengths of merchantable cane and the dry pithy nature of the stalks themselves, due to cankers, cracks, and lack of juice.

There have, of course, been considerable variations from this three-year sequence, depending upon varieties and other circumstances, but it holds to a very large extent.

A second very marked sign is what has commonly been referred to as the canker stage. This occurs more severely on certain varieties than on others, and similarly appears on certain ones before it does on others in point of time. The soft white canes, the Otaheite and Bamboo for instance, are peculiarly subject to it, fields of these varieties often entering this stage in the second year. The *Rayada* and other hardier canes show less of this phase of the disease as a rule, but fields do occur in abundance where these canes are seriously cankered and rendered absolutely worthless.

The cankering is plainly an advanced symptom, since a stool may show mottling through two seasons before it appears, and in one variety (*Sarangola*) only a very little has been noted as yet. The stem lesions or cankers originate and can be found on the internodes before the leaf-sheaths have loosened. At this period the lesions are first noted, as somewhat shrunken areas with a water-soaked appearance, soon becoming medium brown in color, and oval to linear, often irregular, in shape. With the falling of the leaf they pass through various shades of brown and finally to an ashen or dull gray color being still sunken, linear, and often coalescing to form large irregular areas more or less completely covering the entire internode. On the other hand, they may be limited to a few only on each internode. The margins of the lesions are quite distinct. They do not pass from one internode to another, the nodal regions forming a sharp line of demarcation.

Penetration of the tissues is never very deep, hardly more than from one to two milimeters at best, and is often limited to a few layers of cells only. The affected tissues are red but not different in shade or other characteristics from similar effects produced by other causes. There are no other internal symptoms except as noted below.

[1] Mr. Childs, manager of Central Los Caños, has data that show that five-year ratoons that had been infected for several years have produced as high as 25 tons per acre.—EDITOR.

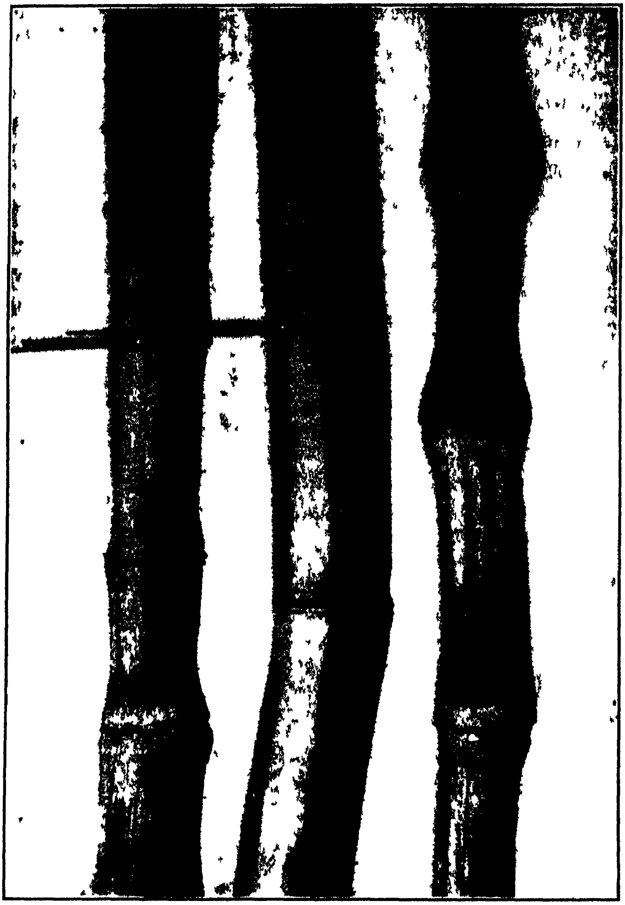

FIG. 4.—Cane stalks; normal in the center, cankered at the sides.

Cracking very often accompanies the cankering, and along these openings the same reddening of the tissues occurs, but it is of the same nature and extent as occurs in splitting of normal cane. Cracking is by no means an uncommon phenomenon; some varieties, and especially large stalks, being very subject to it. For this reason no special significance is attached to it as it occurs in connection with the cankers, other than to consider it a result of drying of the stalks, quite to be expected.

In addition to the stunting or dwarfing of the stools, there is a shrinking of the internodes of the individual stalks. This is especially pronounced in what might be termed third phase cases, or those in the last stages of the disease. Such stalks are almost completely lacking in juice, the limited amount of pith tissue formed being of a rubbery consistency. Where the trouble is not so far advanced the lesions may be present to a greater or less extent without an appreciable shrinkage of the internodes.

One peculiar circumstance that has been often noted in fields in approximately the second phase of the disease has been the finding of stalks showing only part of the internodes cankered. For instance, the lower five or six would be apparently normal and all above cankered and shrunken, or the lower internodes normal with five or six above cankered, and the balance above again apparently healthy. As an extreme case there may be noted a stalk of *Rayada* found above Arecibo, the condition of the internodes of which, proceeding from bottom to top, was recorded as follows: Four normal, five shrunken and cankered, four normal, five shrunken and cankered, top joints to all appearances normal. This sequence is undoubtedly due to an alteration of wet and dry periods.

In every case examined canes showing cankers, even if of one internode only, have also been found to have all the leaves mottled. On the contrary it has been very common to observe field after field showing mottled leaves in abundance but with no stalk cankers present.

There have been reports of apparent recovery from the mottling condition, but it has not been possible to investigate any such cases and they are considered very doubtful at best.

A rotting of the bud is never a sign of this disease and such limited cases as do occur can always be attributed to *Diatraea* or other agencies independent of mottling.

Nothing abnormal has been found in so far as the roots are concerned. As would be expected with cane growing under the conditions which have prevailed in the infected territory, there can always

be found great numbers of dead roots, but no more than in normal cane growing in the same region. The presence of one or more root fungi, of course, often complicated diagnosis, a point discussed under another heading.

Cuttings of normal and mottled cane (B-3922) taken from the same relative parts of the stalks and as nearly equal in size and age as possible were placed in standard nutrient solution. Watch was kept on root development over a period of several weeks or until the cultures were overgrown by molds. At no time was there any observable difference between the two lots.

A series of these cane cuttings were planted in the green house and one of each (normal and diseased) dug up carefully at intervals of a week, beginning as soon as the first shoots broke through the soil. As in the preceding experiment it was not possible to find any differences worthy of note.

It is not believed that there is any noticeable loss in germinating power of seed from affected stalks except those in advanced stages. Nothing of this nature has been noted in the planting tests nor has it been reported or observed in the field, although very little seed visibly infected has been planted, at least in the last year or two.

The symptoms of the mottling disease in brief may be said to be a mottling of the leaves, with no other observable change in the plant at first followed, generally in the first or second ratoons, by a dwarfing of the plant, the presence of cankers or lesions on the stalks, and a decrease in the amount of juice.

OTHER HOSTS.

Constant search has been made for other host pests since the finding of any such might well shed light on the origin of the disease, or make possible the obtaining of other valuable data. Grasses growing in and about cane fields have been particularly watched with this object in view. A number of specimens, for the most part *malojillo* (*Panicum barbinode*, Para grass), were found or sent in by correspondents showing varying amounts of chlorosis. These plants were set out in the plant house and grown for observation. The resulting new growth in all cases was entirely normal indicating that the clorotic condition observed in the field was physiological in nature.

Lyon[1] states that corn (*Zea mays*) is very subject to an infectious chlorosis in Hawaii, closely resembling if not identical with what he designates as "yellow striping" of cane. This condition has

[1] Unpublished note

not been noted as yet in Porto Rico. Longitudinal white stripes of varying width are common on the leaves of the corn here, as well as on certain cane varieties as noted hereafter. They are doubtless of the nature of color chimeras and are therefore of more interest to the plant breeder than the plant pathologist.

The search for other host plants should be continued in order to thoroughly examine into the possibility of the theory advanced by some that the disease has originated on wild grasses in the upland districts and spread from these to the cane.

RELATION OF ENVIRONMENTAL AND CULTURAL FACTORS.

The field survey.

With the aim of inquiring into all possible conditions which might influence the disease directly or indirectly, or even be of a causal nature, various environmental and cultural factors have been studied both in field trips and in plant house experiments.

Throughout the course of the studies a large number of field trips to all parts of the Island and of course to affected districts in particular were made. In addition to those made by the writer, assistants in the division of plant pathology have also aided in this phase of the work, and results here recorded include information based on their reports as well as upon information obtained by correspondence and conversations with other members of the station staff, cane growers, and others interested.

It was realized, however, that while many facts were being obtained in this way, it was desirable to have data in greater detail, and in more orderly arrangement than the above methods permitted. Accordingly a form embodying the points upon which information was desirable was drawn up. The plan was to send out field agents to cover the entire Island as rapidly as possible, one of the forms being filled out for each field visited. This work was well under way before the writer left the Island and had advanced far enough to demonstrate its value. The outline used in this survey is as follows:

FIELD SURVEY—CANE DISEASES.

Field No.-------------

Acreage -------------

Date----------------------------

1. Location--
2. Type of soil--
3. Nature of terrain---
4. Variety---

6. History of the field:
   (*a*) Plant______________________ Ratoon______________________
   (*b*) Previous crops____
   (*c*) Years in cane__________________ (*d*) Rotation __________________
6. Percentage of stools showing mottling__________________________________
   (If more than one variety present, give percentages for each.)
   (*a*) Percentage showing cankered stalks_____________________________
7. When did disease first appear____
8. Source of seed______________________ Did field show disease?__________
9. Cultivation practices.
   Lime ____
   Fertilizer ____
   Extent of plowing, harrowing____
   Seed selection ____
   Seed treatment ____
   Irrigation or drainage____
   Subsequent cultivation ____
   Hoed or cultivated____
   Disposal of trash____
10. Other diseases present: Miscellaneous__________________
    Odontia__________________________ Sclerotium __________________
    Himantia _________________________ Cercospora __________________
    Rind disease______________________ Leaf spots __________________
    Red rot__________________________ Red striping __________________
11. Insects:
    Diatraea__________________________ White grub __________________
    Pseudococcus______________________ Miscellaneous__________________
12. Remarks____

The aim of this outline was several fold, the data to be of use not only to pathological workers but to the entomologists and agronomists as well. It was designed to provide in convenient form the character of cultural practices, the nature of the soil, the history of the occurrence of the disease, and any other information obtainable as to presence of other diseases or injurious insects. Not only was it expected to prove of value in the mottling studies but to serve as a guide in other sugar-cane investigations.

In the following table is given the salient features of a survey of a considerable portion of the sugar-growing lands of the lower Arecibo valley in so far as they apply to mottling in which these forms were used. This work was performed in the summer of 1917 by Mr. E. D. Colón.

Table II.—Results of Field Survey in the Arecibo Valley.

Field No.	Area [1]	Soil	Variety	Years in cane	No. of crops	Disease appeared	% of disease	Remarks
1	236	Silt loam	Rayada	20	Mixed plant and ratoon	1914 (?)	30-95	Disease worse near water courses
2	12	Heavy loan	Rayada	4-5	Plant cane	1917	7	Good cultivation
3	15	Sandy loan	Rayada	30	First ratoon	1916	1	Good cultivation
4	19	Clay	Rayada	11	About third ratoon	1916	47	Fair cultivation Fertilizer applied
5	23	Gravelly loam	Rayada	11	Third ratoon	1916	50	Good cultivation
6	10	Gravel	Rayada	11	Fourth ratoon	1917	10	Good cultivation
7	56	Gravel loam	Rayada	3	Third ratoon	1917	15	Good cultivation
8	38	Sandy loam	Rayada	20 25	Plant cane	1917	5	Good cultivation
9	?	Sandy loam	Rayada	20	First ratoon	1917	1	Good cultivation
10	12	Sandy loam	D-117 B-208 Rayada	20	Plant cane	1917	17	Seed from Experiment Station Good cultivation
11	¼	Sandy loam	B-208	New land	Plant cane	(?)	3	Seed from Experiment Station Good cultivation
12	6	Loam	Rayada	19	Plant cane	1917	5	Seed from Los Caños
13	2	Loam	D-117	8-9	Plant cane	(?)	4	Seed from Experiment Station
14	9	Loam	Crystallina	19	Plant cane	1917	0	Seed from Experiment Station
15	9	Sandy loam	Rayada	12	First ratoon	1917	2¼	Good cultivation
16	23	Sandy to clay	Rayada	2	First ratoon	1916	⅛	Good cultivation
17	73	Sobre-vega	Rayada	12	Fourth ratoon	1917	2-15	Good cultivation
18	93	Silt loam	Rayada	12	Third ratoon	1917	3	Good cultivation
19	11	Clay loam	Rayada	12	Fourth ratoon	1917	Trace	Good cultivation
20	14	Gravelly loam	Rayada	12	Plant cane	1917	10	Good cultivation
21	210	Silt loam	Rayada	20	Third ratoon	1916	Trace	Good cultivation
22	102	Silt loam	Rayada	25-30	Plant cane	1917	10	Good cultivation
23	85	Silt loam	Rayada	7-8	Plant cane	1917	2-3	Good cultivation
24	14	Sandy loam	Rayada	?	Fourth ratoon	1917	1	Good cultivation
25	9	Not given	Rayada	?	First ratoon	1917	1	Good cultivation
26	400	Sandy to loan	Rayada	17	Ratoon replanted	1916	1-2	Good cultivation
27	600	Silt loam	Rayada	30	Ratoon replanted	1916	1-5	Good cultivation
28	400	Silt loam	Rayada	30 +	Ratoon replanted	1916	1-2	Good cultivation

[1] Area in *cuerdas*. *Cuerda* = 1 acre approximately.

A study of the data here presented bears out statements to be enlarged upon further on that soil, variety, years in cane, and other cultural matters have no direct bearing on the disease.

A similar survey was conducted in the Cayey district, an enclosed valley in the interior of the Island, which has been free of disease until comparatively recently. Some two thousand acres in six *barrios* were gone over here by Mr. Juan Simons, Deputy Agricultural Inspector.

A table from his field notes has not been prepared because of its similarity in salient features to the one already given; but his conclusions, adapted from his field report, are as follows:

"In all fields inspected the presence of the mottling disease of cane was noted. The infection varied from three to four per cent in the least diseased fields to sixty per cent or over in the most severe cases, with an average of ten to fifteen per cent.

"It is to be especially noted that plant canes, with three or four exceptions in *barrios* Beatriz and Vegas which had an average of six per cent infection, were as heavily attacked as ratoon canes.

"Ratoon cane with rare exceptions was generally severely attacked by this disease, having in almost all cases more than twenty per cent of mottled stools. In *barrio* Rincón for instance there was an area of more than two hundred and seventy-five acres of ratoons with an average of sixty per cent of mottled stools. Canes from these fields are being used for seed purposes in the new plantations which, of course, means the dissemination of the disease, and hence the high per cent of infection in plant cane.

"The soils in this region are for the most part of heavy clay, but are usually well drained. The fields are mostly hilly or rolling although there are great extensions of plains, but in no case was it noticed that the disease favored any particular class of soil or terrain, being found in equal intensity on hills and lowlands. In general the mottling disease is widely spread throughout the cane region of Cayey."

This will suffice to give an idea of the scope and purpose of the field survey. Most interesting data should result from the complete reports. As these records are made for individual fields, the location and name or number of each field being recorded, it will be possible in selected localities to make a second survey and so obtain information as to the course and behavior of the disease from season to season.

Cultural factors.

Because of the very great importance of cultural methods in their relation to most other cane diseases than the mottling, much attention has been given them throughout the course of these investigations. The cane troubles known as root disease and deterioration are so prevalent on the Island, and so widespread, that too much cannot be said as to the value, and, in fact, the necessity, of proper methods of cultivation, using the word cultivation in the broad sense, even though as is now apparent cultural factors do not in themselves serve to influence mottling.

The reiteration of these recommendations in various publications during the time the disease has been under study, as well as the earnest effort of the various sugar companies and growers to do everything possible to combat the mottling disease, have resulted in a thorough trial of all possibilities in this direction. The results will be briefly summed up below.

Deep plowing has been carried out in a number of localities both by means of steam plows and by tractors which are now well established on the Island. In some places at least, where the disease was present in disastrous amounts the fields been prepared for planting were plowed five and six times. Sufficient fields have been examined which had had excellent cultivation including a number of deep plowings to make it evident that such work was without any practical results as far as control was concerned. As much disease would be present, other conditions being equal, as where shallow holes only were made by hoes and no subsequent cultivation given. There would, of course, be an increased yield and relative freedom from other diseases.

Effect of fertilizers.

Great attention has been paid to the matter of fertilizers. Of recent years it had been found profitable on practically all the cane lands of the Island to apply chemical fertilizers. With the breaking out of the European war the supply was interfered with, certain ingredients becoming unobtainable, and even those available were very high priced. Many growers were inclined to place the blame for the poor condition of the cane on the lack of fertilizer, and they were doubtless correct in so far as yield and other factors, with the exception of mottling, were concerned.

The Insular Experiment Station has conducted over several years a number of very careful fertilizer experiments in various parts of the Island, and more especially in the western portions. Results

of these all appear in the annual reports of the station, and while they show clearly the value of fertilizers, often resulting in as high as fifty per cent gain in yields, there has never been the slightest evidence that there was any effect in controlling, or even in checking, mottling. This has been borne out by fertilizer experiments conducted by some of the sugar companies themselves. The following paragraph taken from a report prepared by Mr. Bourne in charge of experimental work for the South Porto Rico Sugar Company is representative of these tests.

"*Tablón* 7, in addition to its thorough tilling had a fairly good dressing of cow peas. In December 1917, sulphate of ammonia was applied at the rate of 300 pounds per acre to the 7.5 acres of B–3922 in *Tablón* 7. This part of the field was most affected and the sulphate of ammonia was applied to see if it would help to throw off the disease or turn the foliage greener. No change for the better, however, could be seen except that it caused a slight stimulation in its general growth.

"About the same time an experiment was conducted in triplicate plots in *Tablón* 9 with sulphate of ammonia, lime and filter press cake (*cachaza*). The sulphate of ammonia was applied at the rate of 540 pounds per acre, lime at the rate of two tons per acre, and the *cachaza* at the rate of thirty and sixty tons per acre. Check plots were left without any treatment, and up to the present there is no noticeable difference in any of the treated plots to those not treated."

To test the matter under more nearly controlled conditions an experiment was laid out in the plant house. Two-eyed cuttings of the variety B–3922 as nearly comparable as possible were used, ten each of normal and diseased being planted, and each in a separate container. After germination fertilizer of a standard 12–6 formula (twelve units of nitrogen and six of phosphate, potash not being obtainable nor for that matter necessary) was applied as follows: Four ounces to each of four cans, two ounces to each of four cans, leaving two without any applications as checks. Two to four ounces is the usual amount applied per stool in field practice. No effects were seen at any time, other than the slightly better growth of normal cane.

Claims were made that sodium nitrate would "cure" the disease and experiments were in order to prove or disprove this claim. Again using potted cane in the plant house, two ounces of sodium nitrate were applied to each of four cans, and four ounces to each of four, leaving two cans in the row of ten as checks. At the time

of application the canes in all ten cans had reached a height of about two feet and all were typically mottled. The four-ounce application was sufficiently strong to cause the death of the plants to which it was applied. In the case of the two-ounce doses there was a deepening of the green color of the leaves which somewhat obscured the mottling, but otherwise there was no change, and certainly no cure in any sense of the word. It was doubtless this effect, seen without careful examination, that led to the statement made. Where the cane had been killed, replantings of diseased two-eyed seed pieces of B-3922 were made. These suffered the same fate ultimately as their predecessors, showing mottling, however, as long as they were alive. Field tests in various localities have given the same results.

Liming.

Great hopes were at one time entertained as to benefits to be had from liming. As with other possibilities trials were made under varying conditions but with negative results as far as mottling was concerned. In following out this proposition several limed fields in the western section of the Island were very carefully gone over. Moreover a plant house experiment was set up and only served to make the negative results more evident. In this experiment cuttings of the same kind as used in other plant house tests were employed. Ten pots of mottled cane were assigned to this test, two serving as checks, two with a half ounce of air-slacked lime, four with one ounce, and two with two ounces. Lime is of value only in so far as it increases yields.

Ground or powdered limestone has been reported as a certain cure and is said to have been tried out by a number of growers but there does not seem to be any general movement to apply this material. The writer has not been able to locate any fields where it had been applied successfully. As a fertilizing agent it would be of somewhat less value than slacked lime because of its limited availability.

Seed treatment.

Seed treatment at the time of planting has been advocated as a preventive measure for the pineapple disease or black rot (*Thielaviopsis paradoxa*) and has been generally adopted for this purpose. In all publications on the subject it has been clearly stated that the dipping or soaking of cane seed in Bordeaux mixture was not effective for the control of any other disease than the pineapple disease. In spite of this warning, however, Bordeaux treatment has been repeatedly tried in the hope of checking the mottling, and of course

with absolutely negative results. At no time after the infectious nature of the disease became apparent was dipping recommended.

No direct experiments were performed, the experiences of the growers being sufficient, but it may be noted that of several hundred diseased cuttings planted in the green house experiments all were soaked in strong Bordeaux mixture for at least fifteen minutes and without exception all produced mottling shoots.

Ratooning.

In comparison with Santo Domingo and Cuba very limited ratoon crops are possible in Porto Rico, and in fact in large portions of the south coast it is the custom to replant every year. As a general rule not over two ratoon crops are obtained although there are exceptional cases where as high as fifteen or twenty crops have been obtained. In such cases, however, much replanting is necessary every year. In a disease of the nature of mottling there is an accumulative effect which, as has already been pointed out, proves disastrous in the third year or second ratoon in the usual course of events in Porto Rico. Where the disease has gained considerable headway in a given field no further attempt should be made to obtain a ratoon crop but the whole should be plowed up as soon as possible after cutting.

Drainage and irrigation.

These two points while of the very greatest importance in any consideration of root disease, deterioration, or similar cane troubles, do not seem to have the slightest connection with mottling. The results of field observations combined with the data of the field survey fail to indicate any such relation. All types of fields are invaded alike.

Disposition of trash.

This phase of field practice, discussed at some length in an earlier report (26) is now seen to have little effect on the mottling. The stand taken in that report is not receded from in so far as it applies to cane growing independent of the disease. Burning of the trash is a most objectionable practice and every effort should be made to conserve it for the benefits to be derived from its presence on the land. There will be an indirect benefit, even in the disease situation, since proper handling of the trash makes for increased yield which will serve to counterbalance in some measure losses from the disease. As far as the results of the field survey have been examined there is no evidence that burning or non-burning of trash has had any direct influence on the disease.

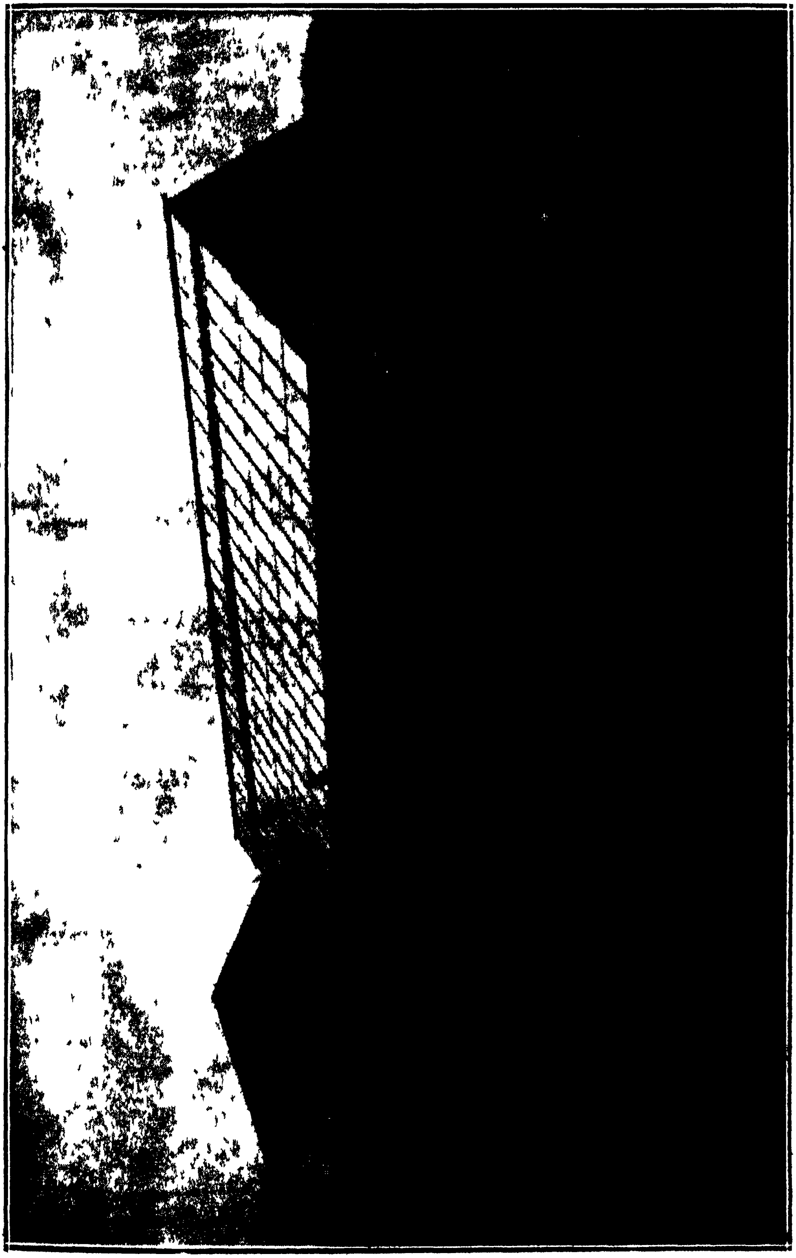

FIG. 5.—Planthouse, north-side view, Insular Experiment Station.

Effect of soils.

As with the preceding topics negative results only can be reported concerning the relation of different soil types. This was a point given consideration in the field survey and, as noted in the discussion under that heading, it was impossible to detect any effect of the different soils on prevalence or absence of the disease. A glance at the table on page — will show that the cane on practically every class of soil varying from sand to the heavy red clay of the uplands is subject to attack.

In tests carried out in the plant house three types of soil were used, a pure white sand such as was being used for building operations, the black loam used in propagating work at the station, and a red clay subsoil. Cuttings used were from diseased and normal stalks of B-3922, cut to two buds or internodes per piece, and all dipped in Bordeaux mixture fifteen minutes before planting. There was never at any time any effects as far as absence, presence, or relative virulence of mottling was concerned. Diseased cuttings produced diseased stalks, the normal cuttings healthy stalks, and there were no changes throughout the season. There was of course great variation in the amount of growth, plants in clay and sand thriving poorly except when aided by chemical fertilizer.

A very striking illustration of the conclusion that the nature of the soil has no effect on the disease is furnished by the field in which the disease first appeared near Río Piedras. The soil was very fertile, had not been planted to cane for many years and gave what was probably the highest yield of any field on the north coast.

Rainfall and soil moisture.

Of the considerable number of theories suggested, the one which warrants most serious consideration is the relation of the weather, and more particularly the periods of drouth to this epidemic. The records of the United States Weather Bureau have been studied in an endeavor to correlate the rainfall, or perhaps the lack of rainfall, with the inception and spread of the mottling, but this has not not been very successful. The greatest difficulty has been in the nature of the rainfall of Porto Rico, which in large part comes in the form of numerous local showers. This means that there is the greatest possible variation in precipitation from locality to locality. For instance, one valley may be suffering from a prolonged drought while only a few miles away there may be a sufficiency of moisture. Therefore if it is found, for example, that the precipitation for Camuy was at a certain figure for any month, it does not

mean that the country directly to the south had the same amount of rain by any manner of means.

Considering the annual precipitation, it is found that Arecibo tends to approach the average for the Island, that Isabela and Camuy fall below, often as much as twenty inches, but that Utuado and the districts east of Arecibo exceed the average. A serious drouth in the region from Arecibo west occurred in the first months of 1916, and was preceded by excessive rainfall during the latter part of 1915. A similar drouth occurred during the first part of 1917 but was not so serious as that of the preceding year. This state of affairs was sufficient to bring on a serious condition of the cane. In fact it had a tendency by the yellowing of the leaves and stunting of stools to obscure the mottling. That it had no relation to the disease is evident when it is considered that Utuado and other districts which had not suffered from these severe drouths, at least as far as the weather records show (Utuado had 21.70 inches of rain from January to April, 1916), have also been severely infected, and that although the season of 1917 was normal as to precipitation the disease spread unchecked.

An experiment to test the effect of the moisture supply was set up in the plant house in the same manner as already described for other tests there, using black loam soil. Half of each of four series of ten cans was planted with normal cuttings, the balance with diseased. The resulting plants were allowed to grow several months, being watered normally or about once a day on the average, until they were about eighteen inches in height and well established. Beginning at this period one series of ten cans was watered to saturation, drainage holes in the bottoms being plugged; one series was watered normally; and two series were watered only at long intervals when wilting became pronounced. About one quart at ten day intervals was the amount given this series. At the end of two months one of these two latter series was treated as the first one, the soil being kept practically saturated for the duration of the experiment. The purpose of this was to simulate the alternation of drouth and long periods of rainfall, such as are of common occurrence in the western sections of the Island.

Normal cane made the better growth in all cases, which condition was particularly noticeable in the heights attained during the first few months. Canes under drouth conditions practically ceased to grow with the cutting off of the water supply and most of the series finally died. Much the same effects resulted in the saturated series. There were no other results.

A similar experiment was set up in three series of ten cans each using the red clay subsoil. These were treated in the same fashion as the preceding except that the alternation series was omitted. It was necessary to supply chemical fertilizer to secure satisfactory growth even in the normally watered series. Here again there was a dying of plants in dry and saturated soils of both normal and diseased lots.

The same series planted in a white sand gave the same results, it also being necessary to supply fertilizer to secure growth. Based on the results of the field survey and the plant house experiments it is a safe conclusion that water supply has no direct influence on the mottling disease.

NATURE OF THE DISEASE AND POSSIBLE CAUSES.

The endeavor to learn definitely the nature of this disease has proven rather baffling, and has led to experiments and studies along a considerable number of lines. Several theories have been tentatively considered from time to time, each of which has in turn given way to another as more facts came to hand. The progress of these studies will be briefly reviewed with the addition of such data as has been obtained since the writing of the last report.

It was first thought that the trouble was a manifestation of deterioration or running out of an old long established variety, the situation being accentuated by unfavorable climatic conditions. This view was soon abandoned because of the spread of the disease to other varieties and to districts where weather conditions had been normal. Much of this deterioration trouble is present, however, in all sections and represents a problem of no little importance, but is so sufficiently distinct that confusion need not arise.

Degeneration, a theory advanced at one time to account for the disease, likewise proves unsuitable in the light of further facts as the following exposition will make clear.

Inoculation tests.

Although all inoculation tests made in the preceding year gave negative results, field evidence proved rather conclusively that the disease had means of transmission other than by infected seed pieces, so that it seemed desirable to make further trials at artificial transfer of the disease.

In the first experiment a typical mottled stalk was ground in an ordinary food chopper and the expressed juice used as the inoculum. A hypodermic needle was employed to make inoculations.

Tallos Cancerosos. Variedad Cavangerie

(Caña de Vino)

Cankered Stalks. Variety Kavangerie.

A convenient plot of cane (Yellow Caledonia) some distance from any infection areas was selected and twenty-two stalks in all stages of growth from six inches in height to mature canes were inoculated. The punctures were made in some instances in the buds, in others at the growing point, and in still others into the internodes. Corresponding stalks were punctured as checks but not inoculated. None of these stalks, neither the inoculated nor the checks, has shown any signs of mottling.

As a second test another diseased stalk was similarly ground to furnish the inoculum and the material applied as before to canes of the variety B–3922 growing in the plant house. Twelve lots were inoculated in various ways with corresponding checks. Results were again negative.

Three series of these experiments were made the year before the varieties involved being Otaheite (*Blanca*), Yellow Caledonia, *Rayada*, D–117 and B–376 for a total of over one hundred inoculations. No positive results were obtained at the time, nor have any of the stools shown mottling in the present season.

Acting on a suggestion that the mottling might be similar to bean mosaic in its reactions, a series of tests was made in the plant house by inserting small bits of diseased tissue into various parts of normal canes. A set of inoculations was also made by rubbing growing tips of a number of healthy stalks after a diseased tip had been crushed in the fingers. It had been found by investigators that the bean mosaic could be transferred in this manner but not by using the expressed juice. There had been no developments from these tests at the last observation.

Chemical tests of the juice.

Limited tests of the juice of diseased canes were made in the division of chemistry of the station, from canes furnished by this division, with particular reference to the glucose ratio and a possible reduction in sugar content. It has not been apparent at any time that data of any great bearing on the problem was obtainable in this direction, but it was considered desirable to try out this possibility in common with all others.

The results of some of these analyses are given in the following table:

Table III.—Chemical Tests of the Juice of Diseased and Normal Canes.

Date 1917	Condition	Source	Variety	Corrected Brix	Sucrose	Purity
July 28	Normal	Cambalache	Rayada	12.28	6 47	52 9
July 28	Diseased	Cambalache	Rayada	12.48	6 88	54.9
September 29	Normal	Rio Piedras	B-376	11 51	6.48	57 60
September 29	Diseased	Rio Piedras	B-376	11.51	6.84	59.42
October 17	Normal	Rio Piedras	B-208	13.88	10.40	74.9
October 17	Diseased	Rio Piedras	B-208	12.68	8.75	69.0
November 8	Normal	Rio Piedras	B-3922	15.84	12.47	78 72
November 8	Diseased	Rio Piedras	B-3922	14 47	12.57	86.86
November 8	Normal	Rio Piedras	B 3922	14 88	11 89	79.90
November 8	Diseased	Rio Piedras	B-3922	14 98	12.20	81.44

It is realized that handmill tests of the juice of one or a few canes only cannot be taken as conclusive, but it is thought that these tests are sufficient for comparative purposes. It seems apparent that canes in the first stages of the disease, that is before the cankers and splitting are present, are but little affected, as far as their sugar content and purity of the juice are concerned. Losses would be due to a reduction in tonnage as indicated in the experiment by Lyon already described. In fact as will be noted from the table diseased canes in some cases actually showed a higher sucrose content than corresponding normal canes. Individual differences in age of cane or other factors explain this, however, since the two lots of cane always came from separate stools of course. It is interesting to note that at least one Central reported the same state of affairs in their mill tests in contrast to others which claimed a high glucose ration. As already noted this high glucose content is thought to be due to the fact that in advanced stages the openings in the rind splits and cankers) permit the entrance of bacteria and fungi with resulting fermentation.

As a final test along this line two lots of cane of the variety B-3922, one diseased and one normal were cut, care being taken to obtain canes as nearly of the same age, size, and other conditions as possible. Two canes of each of these lots were analysed by Mr. J. López Domínguez daily as long as the samples lasted. The results are given in the following table:

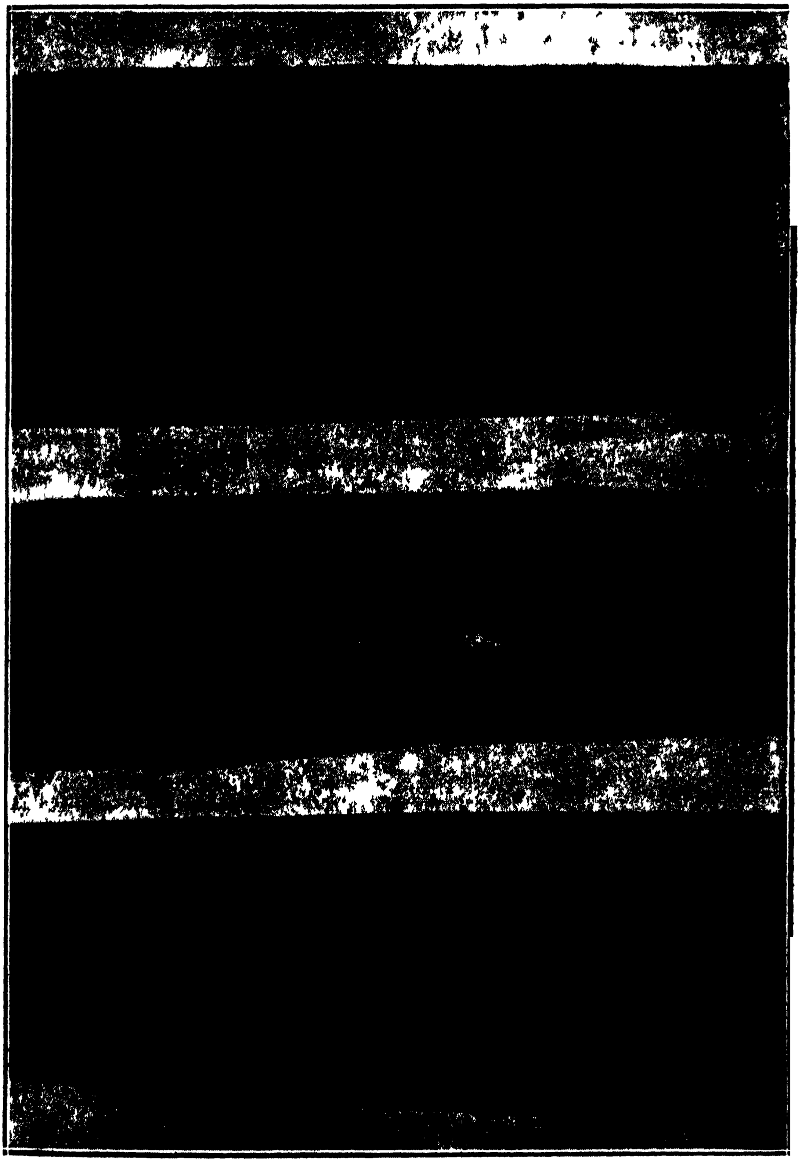

FIG. 6.—Leaf spot of cane (*Helminthosporium sacchari.*)

Table IV.—Chemical Tests of Diseased and Normal Canes.

Date 17	Condition	Brix	Sucrose	Purity
November 13	Normal	14.90	11 96	82.96
November 13	Diseased	15.10	12.00	79.47
November 14	Normal	13.80	10 55	76.44
November 14	Diseased	14.10	10.74	76.17
November 15	Normal	15.20	11.07	72.82
November 15	Diseased	14.20	10.24	72 11
November 16	Normal	13.00	5.42	42.07
November 16	Diseased	13.58	9.45	69 58
November 17	Normal	14 76	9.37	63 48
November 17	Diseased	14.00	8.40	60 00
November 19	Normal	14 93	10.20	68.31
November 19	Diseased	13 53	8.71	64.37
November 20	Normal	15.8	10.8	68.35
November 20	Diseased	15.2	10.06	66.18

Here again no constant differences appear, confirming the results of the previous tests.

Relation of fungi or bacteria.

Leaves.—From the appearance of affected leaves, the presence of fungi or bacteria as causative organisms would not ordinarily be suspected. Early in the work sufficient examinations were made to clear up any doubts as to this point. Microtome and free-hand sections failed to show any differences between normal and diseased leaves other than the absence or deficiency of chlorophyll in the chlorotic spots. A number of attempts were made to obtain by the plating out process a responsible organism but none appeared. Those forms obtained did not occur uniformly and were either plainly saprophytic or the characteristic symptoms produced by them on the leaves when parasitic were well known. They were found on the older leaves for the most part, recently unfolded leaves proving generally free of any organism.

Particular attention was given on field trips to the relation, if any, of the various leaf-spot diseases to mottling but it was never possible to find any such connection. There was practically as much spotting due to *Leptosphaeria sacchari* and *Helminthosporium sacchari* on normal as on mottled cane.

Stalks.—Sufficient work to amply justify the conclusion that organisms attacking the stalk were not directly involved as causes of the disease were carried out last year, and may be here briefly reviewed.

The absence of any distinctive internal symptoms in the form of rot or gumming made it very doubtful from the first whether a parasite would be present. A special search was, of course, made for rind disease (*Melanconium sacchari*), red rot (*Colletotrichum*),

gumming (*Bacterium vascularum*), or other parasitic stalk diseases. Suffice it to say that while isolated cases have been found of the common stalk diseases of Porto Rico (gumming does not occur here) they have not been present to even an extent where appreciable damage was being caused, nor was there any connection with the mottling.

The common, easily recognizable fungi having been eliminated, attention was turned in the laboratory and in the pot cultures to an attempt to find a more obscure parasite or other cause. Tissue cultures and damp chamber tests were made from time to time, both of cankered stalks and of stalks which were normal appearing except for leaf mottling. Cultures of representative cankers made November 1 gave *Valsa* sp. and *Trichoderma lignorum*. On November 11, tissue cultures of stalks of B–208 and Yellow Caledonia proved sterile. In sterile moist chambers sections of the stalks produced a growth of *Trichoderma,* and in one instance of *Schizophyllum*. Seven lots of cankered canes were tested in damp chambers under sterile conditions, beginning December 26. Of these, two remained sterile, one produced *Trichoderma,* and four were overgrown with *Aspergillus niger,* but were otherwise sterile.

Similar tests were made in January of portions of mottle-leafed and cankered stalks brought in for planting tests. Pieces of eight stalks of Otaheite, Rayada, B–3412, and Sarangola produced only the customary saprophytes mentioned above.

A further series of tissue cultures was made, all precautions to obtain sterile conditions being taken. Short sections of stalks were immersed in mercuric bichloride (500–1) for several minutes, rinsed in sterile distilled water, and in the culture chamber, fragments removed with sterile instruments for planting in beef agar plates. The majority remained sterile until completely dried out, *Aspergllus niger* appearing on some, but quite plainly as a contamination.

To still further examine into any possible relation of the more commonly occurring fungi, several inoculation experiments were carried out. In the first of these *Colletrotrichum falcatum* was used as the inoculating agent, and D–117 cane as the host. Ten stalks were punctured with a hypodermic needle and material from a pure culture inserted. Ten other stalks were similarly prepared, except that sterile water was used in place of the fungus. From time to time inoculated stalks were cut and examined. At no time was there any evidence of even the beginning of red rot. The only abnormal sign was the red discoloration around the puncture, such as occurs around any wound. The checks remained without change.

In addition to these laboratory experiments several extensive field tests were carried out with *Colletotrichum falcatum* and other fungi commonly occurring on diseased cane. As mottling did not appear in any of the canes grown in these experimental plots it was evident that the fungi were saprophytic only, or at least had no connection with the mottling. These tests are reported in detail in the 1916–17 report.

Nature of the cankers.

The cankers or lesions on the stalks of badly diseased cane are apparently the result of the general weakening of the stalks. Since, as has already been mentioned, they are first noticed before the leaf-sheaths loosen, and hence before fungus spores or bacteria could have penetrated, they are not primarily due to the action of fungus parasites. This conclusion is borne out by the cultural studies made. The various fungi, which are always present in abundance in and about the cane stools, doubtless are washed down as spores or mycelial fragments behind the leaf-sheaths as soon as these latter become loosened. The lesions already formed are then enlarged in size and depth by their action. They cannot, however, be concerned to any extent as primary agents since otherwise innumerable cases of red rot, rind disease, and other stalk rots would be found, the fungi causing these being omnipresent in all cane fields. Inoculations in an attempt to produce cankers have failed.

Bud tests.

While taking notes on the experiment in the plot of B–3922 a considerable number of stalks were found from time to time which showed mottling on the upper leaves only. When a new stalk became diseased, or rather when it first gave external evidences of being diseased, the mottling symptoms first appeared in the unfolding leaves. All succeeding leaves would then be mottled but the lower leaves would continue green and unchanged. At the transitional region one or more leaves might be marked in part only, for instance for a few inches out from the base, for half the length, or on one side of the mid-rib only.

All such stalks encountered were tagged at the point of transition and after growth had progressed long enough to form a number of nodes above the tag, they were cut for planting tests. These were conducted in the plant house, and the aim was to ascertain as to whether or not the entire stalk contained the virus of the disease, or only the portion above the transitional area. The buds were numbered from the bottom up, the stalk cut into two-eyed

cuttings and the ends tarred. Ordinary soil was employed in which cane had not been previously grown.

Details of the behavior of buds from several characteristic stalks will suffice to show the course of the experiment.

Stalk No. 124.—Cankered above the point where mottled leaves occurred. Shoots from all eyes mottled.

Stalk No. 175.—Cankered and split above the transition. All buds produced mottled shoots.

Stalk No. 2.—No cankering, though the stalk was not normally plump between the nodes. All buds produced mottled shoots which remained so throughout the season.

Stalk No. 193.—Cankers and shrinkage of the stalk present over several internodes below the transition. All shoots produced were mottled.

There were no exceptions to this sort of behavior in any of the series of plantings made of stalks of this nature.

Effect of chemical applications.

One of the possibilities that immediately suggested itself when studies of the disease were undertaken was that it was due to lack of iron, or to inability of affected plants to assimilate sufficient iron in the presence of an excess of some other chemical.

Potted specimens were sprayed with a four per cent solution of ferric ammonium sulphate, iron potassium sulphide, and ferrous sulphate, the only iron compounds at hand at the time. There were absolutely no results from this treatment.

In a latter experiment ferrous sulphate alone was used. Of ten plants, two were left as checks untreated, four were sprayed with a ten per cent solution and four with a five per cent solution. Several grams of the crystalline salt were placed in the soil of each pot. This treatment was repeated three times at intervals of a week. There having been no observable results after a lapse of a month, 125 cubic centimeters of ten per cent solution was poured on the soil of the first four, and the same quantity of five per cent solution on the other four. Again there were no results and the cane was cut to permit it to ratoon. After another month the solutions were again applied as above to the new shoots, but without results. It was apparent that the disease was not related to the chlorosis diseases of pineapple or cane, which have been clearly shown to be due to lack of iron in the soil, or to inability of affected plants in the presence of an excess of iron to assimilate sufficient iron for normal growth.

Copper sulphate was also tried with the view in mind that it might serve to restore normal green color to mottled leaves. Two plants were sponged with a two per cent solution, two with a five per cent. A quantity of each strength was also poured on the soil of each pot. This was repeated twice over a period of two months, but without the slightest effect. Mottled shoots remained mottled at all times.

Manner of transmission of the disease.

A number of tests were made to ascertain as to whether or not the disease was carried over in the seed. For this work five-gallon oil cans only were available, which were rather small for growing cane to maturity. In all of these plantings the seed pieces were recut prior to planting, soaked fifteen minutes in Bordeaux mixture and planted immediately. Unless otherwise noted, the soil has been a fair quality black loam such as is used in all propagation work at the station.

The first planting was made on December 9, seed for checks being taken from fields on the station grounds. Examinations were made from time to time as to the presence or absence of mottling, and the number of shoots produced. Neither in this experiment nor in any of the others was there any apparent correlation between the disease and the number of shoots produced. The results of the first and last examinations only are given unless intervening dates showed facts of importance.

Table V.—Results of First Series of Pot Experiments.

Group	Can No.	Soil	February 8, 1917	July 25, 1917
A	1	Sterilized (steam)	Leaves mottled	Leaves mottled
	2	Untreated	Leaves mottled	Leaves mottled
	3	Untreated	Leaves mottled	Leaves mottled
	4	Untreated	Leaves mottled	Leaves mottled
B	5	Untreated	Leaves mottled	Leaves mottled
	6	Sterilized	Leaves mottled	Leaves mottled
	7	Untreated	Leaves mottled	Leaves mottled
	8	Untreated	Leaves mottled	Leaves mottled
C	9	Sterilized	Leaves mottled	Dead
	10	Untreated	Leaves mottled	Leaves mottled
	11	Untreated	Dead	
D	12	Untreated	Leaves mottled	Leaves mottled
	13	Untreated	Leaves mottled	Leaves mottled
	14	Untreated	Leaves mottled	Dead
	15	Sterilized	Leaves mottled	Leaves mottled
E	16	Sterilized	Leaves not mottled	Leaves doubtful
	17	Untreated	Leaves not mottled	Leaves not mottled
	18	Untreated	Leaves not mottled	Leaves not mottled
F	19	Sterilized	Leaves not mottled	Leaves not mottled
	20	Untreated	Leaves not mottled	Leaves mottled
	21	Untreated	Leaves not mottled	Leaves not mottled

A. *Yellow Caledonia.*—Seed obtained from near Arecibo, plant

cane, seed for which was obtained from this station. It had been planted in soil said never before to have been in cane, although surrounded by diseased fields. The field showed about thirty per cent of mottling, and later the first ratoons were a total failure. This test was made with uncankered stalks, the leaves of which were mottled.

B. *Rayada.*—From near Arecibo, typically mottled and cankered, nodes shrunken.

C. *Yellow Caledonia.*—Same as A, except that the stalks were lightly cankered, and but little shrunken.

D. *Same.*—Stalks very badly cankered and shrunken.

E. *Check. D-117.*—Seed from station fields.

F. *Check. Yellow Caledonia.*—From station fields.

Soil for the second experiment (planted December 13, 1916) was a heavy clay obtained from a field in the Arecibo district, which had been abandoned to cane culture because of the disease. A portion of this was sterilized (cans Nos. 1, 2, 3) by steam (one hour at about sixty pounds pressure), and the remainder untreated. The seed used was the same as that of the first planting.

Table VI.—Results of Second Series of Pot Experiments.

Can No.	Seed	February 8, 1917	July 25, 1917
1[1]	B	Leaves mottled	Leaves mottled
2[1]	D	Leaves mottled	Leaves mottled
3[1]	E, F	Normal	Leaves mottled [2]
4	B	Leaves mottled	Leaves mottled
5	A	Leaves mottled	Leaves mottled
6	A	Normal	Normal
6 a	F	Normal	Leaves mottled
7	F	Normal	Normal
8	D	Leaves mottled	Leaves mottled
9	C	Leaves mottled	Leaves mottled
10	E	Normal	Normal

[1] Soil sterilized.
[2] Mottling was first noted on two out of six shoots on March 6, this proportion continuing until June 25, by which time all were affected.

On December 23, another set of plantings was made in order to obtain further data on canes which were being examined in the laboratory at the time. Steam sterilized soil was used.

1. *Caña de vino* (*Cavengerie*).—A stalk from Camuy, apparently normal but from a stool other stalks of which were showing mottling. In the local test all shoots from buds of this stalk remained normal.

2. *B-3412.*—Stalk of mottled cane obtained near Camuy, seed for which had been sent from this station. Most of the field was showing mottling. All shoots from the piece planted were mottled.

3. *Otaheite.*—From near Camuy, a field showing 100 per cent infection. All shoots produced mottled.

4. *Crystallina.*—A diseased stalk from near Camuy, field showing about fifty per cent of disease. All shoots mottled.

A fourth and final planting experiment was started January 5, using the ordinary station potting soil untreated. The seed was all obtained from various badly diseased fields near Central Alianza.

Table VII.—Results of Fourth Series of Pot Experiments.

Can No.	Variety	Condition of seed	February 8, 1917	July 25, 1917
1	Caña de vino	Normal	Normal	Mottled [1]
1 a	Caña de vino	Diseased	Mottled	Mottled
2	Bamboo	Cankered	Mottled	Mottled
2 a	Bamboo	Diseased	Mottled	Mottled
3	Caña de vino	Normal	Normal	Normal
3 a	Otaheite	Normal	Normal	Normal
4	Bamboo	Cankered, mottled	Mottled	Mottled
4 a	Bamboo (same stool)	Normal	Normal	Mottled
5	Caña de vino	Normal	Mottled	Mottled
6	Caña de vino (same stool)	Mottled	Normal (?)	Doubtful
6 a	Caña de vino (same stool)	Cankered, mottled	Mottled	Mottled
7	Yellow Caledonia	Normal	Normal	Normal
7 a	Yellow Caledonia (same stool)	Cankered, mottled	Mottled	Mottled
8	Rayada	Normal	Mottled	Mottled
8 a	Rayada (same stool)	Mottled	Mottled	Mottled

[1] Changed to diseased condition during May.

These results seem to warrant certain conclusions as to the behavior of diseased canes, although it is recognized that they are by no means conclusive. However, even from the limited tests made it is quite certain that all cane shoots springing from seed pieces which were from cankered or mottled-leaf stalks will be diseased in spite of soil sterilization and disinfection of the seed. One exception only occurred in our tests, and that one was very doubtfully normal.

Of the various seed pieces taken from apparently normal stalks or stools which were diseased in part, about half produced normal shoots and the remainder mottled. This phase of the experiments is rendered uncertain by the fact that a stool of cane under the planting system usually employed in the western portion of the Island consists of the growth from about four seed pieces, and since it is apparent that the disease is transmitted through the individual seed pieces, it is undoubtedly a fact that many instances of planting of one or two diseased seed pieces together with normal ones accounts for the presence of both types of stalks in the same stool. After the first cutting it is difficult to trace the separate plants composing the stool. There have been found, however, examples of normal and mottled shoots arising from the same rhizome. The virus of

the disease is present in all such stalks whether they show outward signs or not, and this fact will account for the results obtained in the above described planting tests with apparently normal stalks from mottled stools.

The above experiments were those conducted in the previous season but the results have been confirmed most conclusively by all work since that time. All plantings, without exception, of cane from mottled stools made in the plant house and field experiments to a total of several hundred produced typically mottled shoots.

The following results from an experiment by Mr. Bourne of Guánica Central add further exact data.

"In January 1918, 100 cuttings taken from diseased stalks of B–3922 were planted in Tablón No. 8 at Santa Rita alongside of 100 cuttings taken from absolutely healthy stalks of the same variety. Both kinds of cuttings gave practically the same germination. Early in March an examination was made and it was found that all the shoots from the diseased cuttings had the mottling disease while those from the healthy cuttings had no sign of the disease. The diseased cuttings were then dug up and destroyed and the space replanted with healthy cuttings which have all germinated. At the time of writing an examination was made of the shoots from the healthy cuttings and about 1.7 per cent of them have developed the disease. From this experiment the importance of carefully selecting cuttings is very evident. It also proves that although a field is planted with healthy cuttings, the cane develops the disease after germination."

It was very important to know before any system of control could be evolved whether the disease remained in the soil or not so that infection of healthy plants could occur from that source. To ascertain this under controlled conditions a series of ten mottled plants were selected in the plant house, the canes cut off at the surface of the soil and the underground portions cut sufficiently to prevent any ratoon growth. Seed pieces of normal B–3922 were then planted in each container. The stool from which the seed was obtained was marked as a check. No mottling appeared on any of the resulting plants throughout the season, nor on the following ratoons. The second series of pot experiments reported gives a further verification of this result.

A series of forty pots was prepared in the same manner, using mottled plants that had been used in other experiments, and replanting with normal B–3922 as before. This test is still under observation but there has been no infection as yet of the new shoots.

Similar experiments have been carried out in other sections of the Island on a field scale with comparable results. Some infection occurs of course in such cases but is explainable by aerial transmission of the disease.

It seems certain that the disease does not persist in the soil and that hence infection does not occur through the roots or rhizomes. It may, however, pass from the underground parts of a diseased plant to a healthy one where the two are in contact, although no certain evidence has been obtained on this point.

It is thus absolutely certain that the mottling disease is transmitted by means of diseased cuttings and this fact serves to explain in considerable part the spread of the disease from field to field, its appearance in fields never before planted to cane, and similar questions. Not only has there been no attempt on the part of many growers to avoid use of such seed until the disease was present in overwhelming amount, but it has too often been true that such material has been planted in preference to healthy seed, since it was possible to sell the latter for grinding while the former was refused.

The use of diseased seed will, however, explain the spread of the disease in part only, and it has become very evident as a result of field observations that there is some other method of transmission. In the absence of fungi or bacteria as causative agents whose transmission could be accounted for by wind, water, and other natural agencies it is rather difficult to arrive at any satisfactory conclusion

In the absence of any exact information the theory of insect transmission will be but mentioned and left for other workers to investigate and report upon. The writer feels certain that insects will be found which are capable of carrying the disease and this will then explain the appearance of the mottling in isolated valleys as well as accounting for its rapid advance from west to east. Wind cannot be considered as a carrier since the advance of the disease has been against the direction of the prevailing trade winds. It is supposed as another part of this hypothesis that these insects or insect occur primarily in the uplands, due to the presence there of wild host grasses, thus accounting for the prevalence of the disease in upland districts, and its rather peculiar behavior in jumping from valley to valley rather than working along the continuous coastal areas. The insects suspected in this connection are small sucking forms known as leaf-hoppers. Further support of this hypothesis is given in the discussion of the similar disease of sugar beets known as "curly-top," where the causal relation of a leaf-hopper has been definitely proven. Aphids (*Sipha flava* and *S. graminis*), and the

mealy bug (*Pseudococcus sacchari*) have been also suggested, but it does not seem possible that these species which are so commonly present can be involved. They were present in abundance in the plant house in spite of precautions to prevent their entry, but there was no transferance of the disease, even though ants which carry them from plant to plant were also very abundant.

Conclusion.

With the mass of evidence presented it seems safe to conclude that the mottling disease of cane is an infectious chlorosis allied to similar diseases of cane, and other crop plants to be mentioned in following pages. It appears that it is not influenced by cultural factors, that fungi or bacteria are not present as causal agents, and that faulty assimilation or nutrition are not responsible.

There is an infectious principle present in all parts of infected plants whether evident externally or not, which is transmitted in cuttings, and has some other mode of aerial transmission not yet ascertained. The causal agent may be considered an ultramicroscopic organism as is known for some animal diseases and has been held responsible in the case of the tobacco mosaic. For those who do not believe in the possibility of such organism there is of course the theory of deranged enzymes. These will be found present of course in either event since enzymes not ordinarily present in healthy cane, or abnormal amounts of those that are always present, would result from the attacks of the ultramicoscopic organisms.

The weak point in this theory lies in the fact that it has not been possible to artificially transmit the disease to healthy plants, although there has been abundant field evidence that such transfers do occur in enormous numbers. This is held to be a problem that will be finally solved by changes in technique or manipulation of the virus. Similar difficulties have been had with other diseases attributed to similar causes.

COMPARISON WITH DISEASES OF A SIMILAR NATURE.

Yellow striping.

A very interesting situation has arisen over the possible identity of mottling and a disease of Java and Hawaii known to the Dutch workers as "Gele Strepenziekte" or yellow striping as the name has been translated and applied in Hawaii. Lyon [1] of the Hawaiian Sugar Planter's Station in commenting on the writer's paper (32) published in phytopathology first directed attention to this possi-

[1] Unpublished note.

bility. In fact he went further insisting that they were identical and insinuating that the mottling was neither "new to Porto Rico" nor "alarming" as stated in the article in question. In passing it may be pointed out that the figures already given will testify to the alarming nature of the disease and it is quite certainly new to the Island. No claim was made as to its being new to any other part of the world.

The "Gele Strepenziekte" was first mentioned by van Musschenbroek (37) in 1892 and in the following year Wakker (38) published on the same disease. Since that time there have been a number of other articles dealing with it in the Javan sugar-cane literature, which will be found listed in the bibliography appended. Both Wakker and Went (39), and Krüger (18) deal briefly with it. It is said to have been first noted in Hawaii in 1909. The report of its occurrence there as well as a number of articles published since, dealing with the nature and prevalence of the disease have appeared in the Hawaiian Sugar Planter's Record, which publication has not of course been available for reference.

Concerning this yellow stripe disease Lyon writes as follows.

"It is an infectious chlorosis akin to the mosaic disease of tobacco, The causal agent operates at the growing point of the stem and in the unexpanded leaves which are rolled up in the spindle. Every lateral bud is infected as it is formed, so the disease is certain to be transmitted through cuttings from infected stalks. All varieties of cane growing in Hawaii are susceptible to this disease, but some much more than others. Likewise some varieties are far more sensitive to the disease than others, while others stand up well under the disease.

"In Java and Hawaii the disease is held under practical control by the selection of healthy sticks only for cuttings.

"We have authentic records of the occurrence of yellow stripe disease in Hawaii, Fiji, Australia, New Guinea, Java, the Philippines, and Egypt."

With the exception of the brief paragraph in Krüger's work, none of the Javan references were seen until after the writer's connection with the mottling work had been ended. Since then several of the more important ones have been obtained. In particular the plates in the article by Wilbrink and Ledeboer (40) were examined, and while these illustrate a phenomenon which resembles mottling, considerable doubt is still entertained as to the identity of the Porto Rican and Javan diseases. As far as the writer is concerned it has

not been thought advisable to jump to the conclusion that the two diseases are identical since specimens of the yellow striping have not been available for comparison.

Lyon as noted has been positive of this identity basing his opinion on an earlier paper (32) of the writer. Since then it is reported that he has examined authentic Porto Rican material and confirmed his preventious diagnosis.

Sereh.

A very baffling disease of cane known as sereh has been present for many years in Java having been epidemic at one time. It has also been reported from other eastern cane-growing countries. It resembles mottling in some respects so that a short comparison of the two as to signs and characteristics will not be out of place. Dr. Smith's (25) account of the Sereh is followed in the main.

"The sereh appears at first only sporadically; the year following one finds usually sereh plants everywhere and the third year the disease occurs in such severity (when no measures are taken againt it) that a failure of the crop results." This corresponds very well to the course of the mottling disease. Other signs are also in close agreement, principal of which are the transmission of the disease from old plants to new ones by means of cuttings and a shortening of the internodes. On the other hand sereh is described with a number of points not noted in connection with mottling important of which are the presence of gum, slime, or crystals in the bundles or parenchyma tissues of the stalk, red staining of the bundles, yellow stripes (not mottling) of the leaves, excessive production of new shoots and roots above ground, the clinging of the leaves beyond the usual time of falling, and the dying of the foliage from below upward so that apparently the top of the cane is less diseased. Certain other points, particularly the inclination to bloom early, have not been noted sufficiently well to be contrasted. In addition the Porto Rican disease possesses the very characteristic mottling and cankering of the stalks lacking in sereh.

Every possible cause has been asigned by one worker or another to sereh, including plant and animal parasites to a considerable number, unfavorable soil conditions, wrong fertilizers, abnormal weather (drouth or excess of water), degeneration, dying of the roots, and improper cultivation practices. Workers on the disease have not settled on any definite cause as yet.

Without, of course, ever having had any experience or direct knowledge of sereh, the writer is very much inclined to believe that

the mottling is a disease of the same nature and that both are due to ultramicroscopic organisms.

Curley-top of sugar beets.

A study of the literature on the "curly-top" of sugar beets has shown many points of agreement with mottling, and the desease is of especial interest because of the relation of a certain insect as the carrier of the infecting agent.

This is a disease which causes a distortion of sugar beet leaves, and a dwarfing of the plants with an accompanying reduction in yield. The losses vary from season to season but have often reached $1,000,000 in the western United States. Various theories have advanced from time to time but it was finally proven by Ball (4) that a leafhopper (*Eutettis tenella*) was responsible for transmission of the disease, and this conclusion has been verified by other workers. The insect in question is a native species found on a number of indigenous plants. Under certain conditions these insects pass in swarms to the sugar-beet fields, the curly-top developing soon after.

It was found that leafhoppers "taken from wild plants did not transmit the disease until they fed on diseased hosts. Three hours on a beet rendered them pathogenic. It is probable that some wild plant carries the disease and leafhoppers coming from this plant are able to transmit it to the beets" (Ball).

A most interesting feature of the work on this disease as it relates to the sugar-cane situation is the fact that it has never been possible to transfer the disease by inoculations, although it has been transferred by grafting. Mottling could of course also be transferred in this manner if grafting of monocotyledons was possible.

Tobacco mosaic.

Probably the best known of the diseases of this class is the tobacco mosaic (2, 6), which occurs in practically every tobacco growing country in the world including Porto Rico. Affected leaves are mottled or blotched and in other than light cases distorted. Diseased plants are greatly stunted. Although the disease is highly infectious it has never been possible to find fungi or bacteria present as causal agents. It is very easy to transmit the disease to unaffected plants by rubbing them lightly with the fingers after crushing a diseased leaf. In fact a great number of plants can be infected by an exceedingly small quantity of the virus, and it is by handling that the infection is spread to a large extent.

Two theories are held as to the cause, one considers ultramicroscopic organisms as the causal agent, the other enzymes or the

product of enzyme activities. The former seems the preferable theory. Insects, particularly one or more species of aphids have been demonstrated to be capable of carrying the virus. The striking point of difference between tobacco mosaic and cane mottling is the failure to date to carry out artificial transmission of the latter, which is so easily done with the former.

Spinach blight.

Spinach blight (21) is a disease of the trucking region of the eastern United States, and has caused annual losses as high as $200,000. It is a specific disease characterized by a mottling and transformation of the leaves, and a decided stunting of the growth. Diseased plants may occur in definite areas or they may be scattered over the field.

Fungi or bacteria have never been found associated as causal agents. Nature of the soil, fertilizers, drainage, and other cultural factors, though all considered at different times have been found to be without any direct relation to the disease.

It has been possible to transmit the blight by transfers of the juice of infected plants. Certain species of aphids and one in particular (*Macrosiphum solanifolii*), have been demonstrated to be carriers of the virus and very interesting data has been collected on the relation of these insects to the disease. The causal agent is considered to be an ultramicroscopic organism.

Peach yellows.

Peach yellows has been known in the United States for considerably over a hundred years and has caused very heavy losses. It is characterized by a premature ripening of the fruit which is red spotted as well as being of poor quality. Slender abnormal appearing shoots are produced from the trunk, which bear pale yellowish-green leaves. Leaves on the normal branches may also be yellowish-green.

No remedy has ever been found and infected trees invariably die after a number of years. Pruning of infected branches is always without avail, the virus being present in all parts of infected trees, even though portions appear normal. Control is secured by dugging out diseased trees as fast as they are discovered.

The usual range of supposed causes including poor culture, wet or dry weather, wrong fertilization, insects, fungi, and over bearing has been gone over by various workers and all finally shown to be of indirect importance only. Here again the cause is doubtless an ultramicroscopic organism, although the enzyme theory has also been advanced. No insects have as yet been found which act as carriers.

It has been found possible to infect healthy trees by budding or grafting in diseased material.

Cucumber mosaic.

A disease, which has but recently made its appearance in the middle west where it is said to be the most serious disease of the crop present, is the cucumber mosaic. Typical mosaic symptoms are produced with a pronounced dwarfing or even final death of infected plants.

It has been found possible to transmit the disease artificially by inoculations, and the striped cucumber beetle has also been proven a carrier of the infective principle. The disease has not been found to carry over in the soil or to be carried in the seed. A number of other species of the *Cucurbitaceae* have been found susceptible upon inoculation, but the same is not true with beans, tomatoes, potatoes, tobacco, or other non-cucurbitaceous plants. Those who have worked on the disease consider the cause to be still in doubt, but from the facts known concerning it seems to fall readily into the class of diseases under consideration.

Potato mosaic and related abnormalities.

Under this heading may be grouped for discussion those diseases or abnormalities of potatoes variously known as mosaic, curly dwarf, and leaf curl. By some workers they have been considered as merely varying phases of one disease and by others as distinct. They are sufficiently alike to indicate the same or closely similar causes.

Leaf roll is characterized by an upward rolling of the leaflets at the tips of the branches or even of the entire plant in severe cases. The normal green color becomes yellowish often with a red tinge. Affected plants are stunted. In the curly dwarf condition stems and leaves are shorter than normal, resulting in a dwarfing of the plants. The leaves are normal in color, but wrinkled and curled downward. The leaves of mosaic plants are, as the term implies, mottled and often wrinkled, resembling the same condition in tobacco leaves. All three of these abnormalities are transmitted through the tubers.

Most of the investigators who have considered these potato disease have decided that they were non-parasitic, and have favored the degeneration theory as an explanation. Prof. Stewart has summed up his observations as follows:

"A striking feature of the study was the frequency with which the progeny of plants having normal foliage and high yield suddenly degenerated into worthless dwarfs."

"There is no evidence that any one of the forms of degeneration named is communicable from one plant to another except through the medium of the seed tubers. They are not due to any parasitic organism, neither are unfavorable soil or weather conditions of the current season responsible.

"Neither normal foliage nor high yield is a guaranty of productivity in the progeny of the following season. Degeneration may occur quite suddenly.

"It is unsafe to select seed potatoes from fields containing many degenerate plants. Even the normal plants from such fields are liable to produce worthless progeny."

In the report of last year the writer applied the above conclusions to the mottling disease and so asigned it to degeneration. The further evidence obtained since that time very effectively combats this tentative theory and likewise leads to doubt as to validity of degeneration as a cause for the potato troubles. They would seem to belong more nearly in the infectious chlorosis group of diseases. Such a theory better explains the various phenomena reported, such as the sudden appearance of disease or "degeneration" and its manner of spreading.

A disease of beans also known as mosaic has been reported which clearly belongs to this group of diseases due to ultramicroscopic organisms or infectious virus. There are doubtless others as yet unstudied.

ABNORMALITIES WHICH MIGHT BE CONFUSED.

There are a number of abnormalities of cane due for the most part to non-parasitic causes which occur wide spread in Porto Rico and which can be and often are confused with mottling.

Deterioration.

This term is applied to the general unsatisfactory condition of cane so common in Porto Rico and apparently in all other parts of the world as well judging from the literature, which varies from a mere lack of vigor to a "running out." It is readily attributable to long continued cultivation of one variety, to unfavorable weather, to poor cultivation, and any other factor which tends to reduce the vigor of the plants. Harrison (13), who has given the most extended account of this matter, presents five principle causes for the deterioration or running out of cane varieties, basing his conclusions on observations of the downfall of the Bourbon variety in the West Indies. These causes are as follows:

"(1) Lack of vigor induced by continuous cultivation in the same soil.

"(2) Continuous cultivation of the land to the same depth.

"(3) No care being taken in the selection of suitable material for planting purposes.

"(4) Spread of diseases.

"(5) Changes in the varieties themselves."

The first three of these are primarily responsible for deterioration, at least under Porto Rican conditions; the fourth has, as far as the present situation is concerned, been eliminated; and the fifth is an indefinite statement but one which applies very well and helps to explain such points as why certain varieties after thriving for a time begin to fail.

The first symptoms as noted in the leaves may readily be confused with those of mottling. In fact, the spots or discolored areas can with certainity be distinguished only by their color, which is of a decided yellow rather than the white or nearwhite of the mottling disease. They are not to be differentiated from the yellow spotting described on a following page.

When the unfavorable circumstances persist, the deterioration becomes more marked, resulting in a dwarfing of the stools, dying of the leavesand roots, and general appearance of unthriftiness. It becomes especially marked in each successive ratoon crop, and if the field be not abandoned an exceedingly large number of stools die each season In these advanced stages the rhizome and base of the plant will be thoroughly rotted and permeated by the white mycelium of one or more fungi (*Himantia stellifera* occurs most commonly). It is this situation that has lead to the designation of this condition as "root disease" by many writers.

Deterioration is wide spread in Porto Rico, being especially common in its early stage for instance, where unsuitable varieties are being grown, where cultivation and fertilization have been delayed in heavy soils, or during periods of drouth. The fact that there is a recovery (that is the new leaves are normal) from this stage and that the growers have confused it with mottling, probably explains certain persistant claims that the latter disease has been "cured" by fertilization or other methods.

The former has always been a prominent factor in cane cultivation in the western portion of the Island because of drouth and cultural conditions prevailing there, and is still, of course, very much in evidence and still causing heavy loss. Innumerable cases

occur where it acts in connection with mottling, but sufficient observations and tests have been made to indicate that it is distinct from the latter malady.

The presence of a non-parasitic type of root disease resulting in deterioration has been recognized by other workers, particularly in Java. Wakker reports an hereditary constitutional disease characterized by yellow spots in the leaves, and Kamarling and Suringer (16, 17) studied a root disease due to a compacting of a heavy soil.

Root disease.

In addition to the above, there is another and somewhat similar disease quite clearly, however, parasitic in its nature. Several fungi occur in and about cane stools suffering from this type of disease. *Marasmius sacchari* has been the one most commonly held responsible but the writer does not believe that it is at all concerned. The stellate crystal fungus (*Himantia stellifera*) and the granular leaf-sheath fungus (*Odontia saccharicola*), the latter probably the perfect stage of the former, are of even more common occurrence. As already noted elsewhere (15) the entire matter of the relationships of these various fungi, and their connection with root disease of cane, is a subject requiring definite experiments under controlled conditions before exact statement can be made.

In typical cases of root disease there is no spotting of the leaves, other than that they are very susceptible to *Leptosphaeria*. They die back uniformly from the tips and along the margins, the lower ones dying first. For some time, except for the dead and dying roots and leaves, no other symptoms appear. Finally, however, one or other of the fungi mentioned grows up around the stalk binding the leaf-sheaths rather firmly together with a white mycelial mat. A musty odor is present. Practically none of this disease has been encountered in the territory where the mottling prevails.

Chlorosis.

Prominent among the abnormalities which have been confused with mottling is the whitening or yellowing of the cane leaves known as chlorosis which occurs only in a limited area on the south coast. This trouble is found generally in small definite areas from a few feet to an acre or so in extent. All canes in the given area will be affected so that the spots stand out prominently from the surrounding cane. Individual stools may be considerably stunted, and the leaves yellow to white in color. The discoloration in this case is uniform with no trace of a mottled appearance.

The cause has been definitely shown by Gile (12) to be due to

inability of the cane plant to assimilate sufficient iron due to the presence of an excess of lime in the soil. This trouble can be overcome to some extent by applications of manure and ferrous sulphate applied as a spray.

Yellow spotting.

Another very common abnormality of cane leaves and one which is wide spread in all parts of the Island is what has been designated as yellow spotting. Certain varieties notably Yellow Caledonia and B–1809 are very susceptible to it. It is characterized by small yellow spots with indefinite margins very much resembling the markings of mottling except that the latter are more nearly white, and generally more linear. A further point of difference lies in the fact that this yellow spotting attacks the lower leaves first, new leaves issuing from the bud being always of normal color. Yellow spoted leaves are very subject to *Leptosphaeria,* and other leaf spots, and very often fall prematurely.

This condition in the early stages yields to an increase in the moisture supply, and especially to fertilization and improved cultivation. It is not transmissible through the seed, except in so far as a general tendency to the trouble is concerned when conditions are not of the best. This phenomenon is to be considered as the first stage of deterioration.

White-striping.

There is a striping of cane leaves, already referred to as a chimera, which is common particularly on certain varieties. This consists of stripes of varying width, rarely including the better part of an entire leaf, and running the length of the blade. These stripes are of non-parasitic origen, and result from little understood reactions of a cell or group of cells at the growing point of the stalk. The same phenomenon is common on Indian corn (*Zea mays*).

Mite injury.

At one point of the work with the cane in the plant-house a phenomenon appeared on many of the plants which was practically identical with mottling. This was due to an undetermined mite very similar to the common red spider which is so common as a green house pest. In several instances the only way in which it was possible to make certain which was which was to unroll the young still-folded leaves at the center of the plant. If a mottled condition did not appear on these, the markings were mite work. These pests were finally checked through the workings of natural agencies.

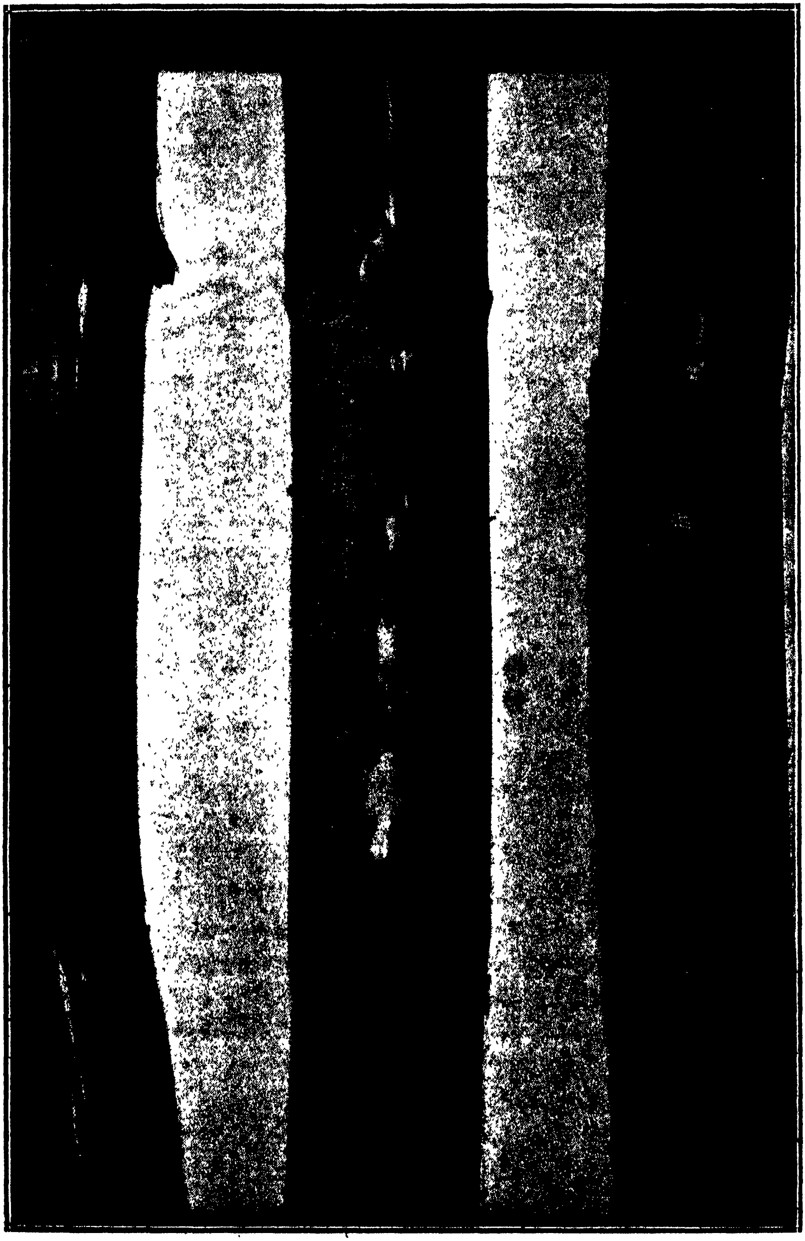

FIG. 7.—Cane-sugar stalks, showing effect of sun burn.

Gray blotch.

This phenomenon consists of gray, very irregular patches (Pl. IV) on the internodes which often coalesce to encircle and practically cover the entire surface. They do not pass from one internode to another. These areas are superficial, including only the outermost layers of cells or practically the epiderm only. Certain varieties, notably B-347, are very susceptible to these markings. It appears probable that they are merely a result of sunburn, since they have been observed on stalks at the edges of fields or in positions exposed to the direct light. Fungi and bacteria may be helpers or secondary agents.

COMPARISON WITH OTHER CANE EPIDEMICS.

As a matter of general interest it is proposed to give a brief account of certain other cane disease epidemics of the past which will to some extent at least throw light on the present situation.

The Porto Rican Epidemic of 1872-80.

There have been several other serious epidemics of cane disease in Porto Rico before the present one. The one entailing the greatest loss (estimated at $796,500) occurred between the years 1872-80, reaching its height about 1876. A commission of three local men was appointed by the Government to study the disease and in 1878 they presented a lengthy report (1). The region infected as given in this publication, included the cane lands around Mayagüez, Aguadilla, Hormigueros, San Germán, Cabo Rojo, and to a limited extent some territory beyond these municipalities, both on the north and south coasts. This was what constituted the fourth department of the Island.

In many respects the observations of the commission corresponded with those noted for the present trouble. The disease spread rapidly, quite irregularly, and was not checked by rivers or hills. The symptoms are described as follows:

"Los fenómenos que presagian el principio de la enfermedad son regularmente cierto tinte amarillento que se nota sobre los cañaverales, el desarrollo tardío y difícil de las cañas, y una vez cosechadas y molidas, la baja en el rendimiento. Al año siguiente, en las cañas que nacen, al parecer buenas y lozanas, reaparece el tinte amarillento del primer período y continúan así hasta 4 ó 5 meses, que corresponden al desarrollo de los primeros cañutos.

"Después continúa el color verde amarillento en todas las hojas que acaban por secarse, primero las inferiores y sucesivamente las

demás, mientras los cañutos que van saliendo permanecen cortos y delgados; la yema terminal o cogollo se seca a su vez, y por fin, arrugándose primero los cañutos superiores o más débiles y después toda la caña, termina ésta por secarse completamente.

"Cañas enfermas procedentes de cañaverales enfermos, sembradas en terrenos sanos y distantes del foco de la enfermedad han producido cañas sanas, y cañas sanas extraídas de las más excelentes cañaverales, transplantadas a los que sufren o sufrieron han producido cañas enfermas."

There were no other consistent symptoms. The occasional cases of internal red rot and rot of the buds were probably due to specific causes. The common cane insects were studied and a decision made that they were not directly concerned. A study was also made of weather conditions with particular reference to drouth, but it was found impossible to make any correlations. All measures such as increased fertilization, use of lime, ashes, and a number of chemical poisons were without effect. The commission after frankly admitting that they had been unable to find a cause advised the immediate extension of planting of several hardy varieties, particularly Morada and Crystallina in place of the universally grown white cane (Otaheite), which had shown no resistance. They also advocated the introduction to the Island of new varieties from other parts of the world.

While in some respects this epidemic resembled the one now raging the perusal of the symptoms as compared with those of the latter does not make it seem probable that they are the same. No reference is made to mottling or stem cankers, but to a yellowing of the leaves only, followed by a drying of the bud.

Some years later Don Manuel Fernández Umpierre (11), administrator of Central San Vicente, published in his work on sugar-cane an account of the same epidemic and his experiences in controlling it. According to his statements, the disease yielded to careful cultivation with particular attention to drainage, even though the very susceptible Otaheite was used. It is quite probable that by the time he took up the problem the disease had about run its course, and even at its height it had hardly extended as far east as San Vicente. Other points, such as origin of the seed used in his experiments, are not sufficiently clear to warrant further discussion of this paper.

In 1895, Don Fernando López Tuero, director of an experiment station (not the present station) published (19) as part of his work on sugar-cane a lengthy article on what he considered to be the same disease. After investigation of a number of possible factors

he decided that white grubs (*Phyllophaga* spp.) are responsible, and proves this theory to his own satisfaction by a series of field observations and planting tests. The present writer inclines to the belief, after a close perusal of López's paper that he was correct in his surmise that white grubs were responsible for the death of cane over large areas. His description at least does not suggest the mottling disease, but is fairly exact for white grub injury.

Other Porto Rican cane disease epidemics.

This, so far as known, includes all recorded cane disease epidemics of any importance up to 1907. About this year trouble was again experienced with the Otaheite variety, this time in the Naguabo district. The disease here was very clearly a deterioration of a long planted variety brought about by rind (*Melanconium sacchari*) and root disease (*Marasmius, Odontia*), and other unfavorable conditions. The symptoms were characteristic in all respects for these two maladies, and no signs of mottling were seen at any time. The situation was overcome by the introduction of new varieties to replace the white (Otaheite).

It thus appears that although Porto Rico has suffered from severe epidemics of cane disease in the past, the present peculiar type has not occurred heretofore. Not only has the literature failed to bring out anything suggestive of it, but conversations with old residents who had personal knowledge of the sick cane of 1872–78 does not make it all probable that the two were the same, at least in so far as visual symptoms are concerned.

Serious cane disease in other cane regions.

Practically every sugar-cane growing country in the world has suffered at one time or another heavy loss from disease, deterioration, or a combination of the two. For example, Porto Rico 1872–78, Mauritius 1841, and again in 1872, Java 1882, Antigua and others of the British West Indies 1895–99. Some of these visitations have been due to unknown causes, others have been designated as rind disease, sereh, or root disease. As a matter of fact most of them come under the head of deterioration. In a considerable number of these epidemics the Otaheite or Bourbon cane has been involved.

One of the most striking instances of this kind was the running out of this variety over a number of years (1895–99) in Barbados, Antigua, and others of the British West Indies. This has always been ascribed to the rind disease, and was satisfactorily checked by the substitution of new and more resistant varieties, a measure which has served to overcome the various epidemics as well.

During recent years the Lahaina cane of Hawaii (probably the same as the Otaheite) has been failing in certain districts, giving rise to what is known as the "Lahaina trouble." Various agencies have at one time or another been held responsible, top-rot, stellate crystal fungus, poor drainage, senility, and others but the actual cause is still obscure. New varieties and possible changes in cultivation and fertilization seem to be the control measures now being tried.

It is apparent that the system which had universally prevailed in all cane countries, at least until serious diseases have appeared, of growing one variety to the practical exclusion of all others, has resulted in all of them, though at different times, in a deterioration of the plants so decided as to assume the proportions of an epidemic. In each instance secondary factors, such as rind disease and other fungi, have appeared, so that the visual symptoms have varied over a considerable range, though the underlying causes were the same.

Rind disease.

Principally because of resemblances to the "rind" disease epidemic of the British West Indies particular attention was given to a search for this disease. The drying and shrinking of the stalks from the top downward with consequent death of the leaves and the final production of the innumerable conidial masses was conspicuously absent, much less being found in mottled fields than occurred in normal fields elsewhere. Not even in abandoned third phase fields could *Melanconium* be found, except in isolated cases. Near Camuy a field of Rayada of nearly fifty acres was discovered which it had not been possible to cut for the mill, and which was being left until the following season. Not a sign of mottling was present, but it was fast approaching total loss due to rind disease.

No evidence has been obtained to bear out the theory that *Melanconium* may be present in stalks which appear normal.

Gumming.

The question will arise in the minds of many as to whether or not mottling is connected with gumming disease (*Bacterium vascularum*) of sugar-cane, if not in fact that identical disease. A summary of the symptoms of this latter disease, practically none of which apply to mottling, should clear up this ponit. Quoting Dr. Erwin F. Smith (25), "The most conspicuous signs of this disease (gumming) are dwarfing, striping of the leaves, drying of the tops, decay of the heart (terminal bud), and the appearance of a yellow

slime or gum in the bundles of the stems and leaves. Many of the bundles are also stained red."

CONTROL.

Particular attention naturally has been given to the very important subject of control, and a number of popular accounts (33, 34) of the disease have dealt largely with this topic. It has been necessary to modify from time to time the measures recommended as further data on the course and nature of mottling became available, but with the definite knowledge now at hand it is possible to outline a satisfactory system for control.

It will be noted that it is control measures and not remedies or a "cure" that it is proposed to discuss. It has at all times been apparent to those working on the problem that a remedy was out of the question, although this has been the persistent demand of many of the cane growers. Much time and effort have been expended in attempting to combat theories based on such views and to make clear the fact that a plant once it is attacked remains so, and that there is but one thing to be done with it—destroy it to prevent spread of infection.

Several instances have been reported of individuals who were offering remedies for sale. It was never possible to obtain samples of these products nor definite information concerning them nor does it appear that any results were obtained from their use, if indeed they were ever used.

A suggestion was made in last year's report that where the percentage was not too high, diseased stools should be dug out and destroyed. At the time the idea in mind for the most part was to prevent any chance of diseased material being taken for seed. When, however, the infectious nature of the disease became so clearly evident, an experiment started for studying the spread of the disease (already described) was changed to one for eradication. The chart (Fig. 2) will show the number of stools dug from the field up to November first. Since that time several additional scoutings have been made and a considerable number of newly diseased stools removed. In the beginning of this work mottled stalks only were removed in order to ascertain whether the disease would appear later in other portions of the same stool. This was what actually occurred in all cases, so that it can be stated that in attempting eradication work entire stools should be removed no matter now few stalks actually show mottling. This partial removal complicated the task of eradicating the disease in the field in question, as did

the fact that it had been permitted to spread unchecked over one full season However, results in the main have been satisfactory.

Some attempts on a field scale have been made to eradicate the disease by digging out of affected stools, but the difficulty of securing the united or continuous effort necessary to insure the success of an undertaking of this nature has made its thorough carrying out almost impossible. Apparently only the prospect of complete ruin can force this action.

One specific case has been under observation for the past two seasons where work of this kind has been in progress. This is a *finca* of about 500 acres situated in a badly infected district. In addition to digging out diseased stools at the time the cane is about two feet high, the best of culture including seed selection, liming, fertilization, deep plowing, and similar measures have been practiced. The white cane has been eliminated and the hardier Rayada and Cavengerie canes are being used. The fields composing this tract are contiguous on two sides to other cane fields which have been given ordinary care only and are badly diseased, so that the whole constitutes a severe test of the eradication proposition. Results have been very favorable and form an object lesson of what could be accomplished by united action.

The value of seed selection with elimination of seed from diseased stalks should not need more than passing mention because of its already demonstrated relation to control. All experiments and field observations prove absolutely that diseased cane always results from diseased seed, hence the vital necessity of eliminating it. This has been ignored by many of the growers or at least not thoroughly attended to.

There is of course a difficutly experienced at this point because of the fact that seed pieces may be diseased without giving outward signs once the leaves are removed. Cankered pieces could of course be readily eliminated. This problem brings up again the advisability of cutting out mottled stools before the cane reaches any great height. Some infection will doubtless occur after the cane has closed in and is of such a height as to make it inadvisable to scout the fields further, but the amount would be reduced to a minimum.

The ultimate solution of the problem lies in the finding of immune or at least strongly resistant varieties as is the case with so many tropical plant disease problems. Several of the seedlings produced by the Insular Experiment Station and tried out in infected

[1] The plan of eradication proposed in Circular 14 of the Insular Experiment Station, Río Piedras, P. R, has been widely adopted on this Island —EDITOR

areas, give promise but certain results can only be secured by trials carried out over a series of years. Since a disease similar if not identical to the mottling, occurs in Java and Hawaii and is there kept in check by resistant varieties it is not at all improbable that some of these will prove of value in Porto Rico. Lyon in this connection suggests the striped Mexican (which seems to be the same as the striped or Rayada of Porto Rico), D–1135, and Badilla, all of which are reported "as very resistant to yellow striping."

Even though it has been shown that cultural factors are not directly concerned with the presence or absence of mottling or its relative virulence, it must not be lost sight of that these are still matters of vital importance to the cane growers, and should be given constant attention since other diseases are always present in Porto Rican fields, and may easily cause serious damage if neglected. Improved cultural methods will give greatly increased yields in spite of the presence of the disease and so help to overcome the losses due to its occurrence.

The measures recommended then for control may be briefly summed up as follows:

Seed should not be taken from diseased stools. Certain fields should be assigned to seed production and a determined effort made to clear of mottling by digging out any stools which become infected.

Seriously diseased fields or those where the returns will be so reduced by the presence of the disease as not to cover expenses should be plowed up. Because of the great number of volunteer diseased shoots that would appear, replanting immediately should be done only in case of necessity, and then only after very careful preparation of the soil.

Where the amount of disease present is not over a small per cent of the total number of stools, an attempt should be made to eradicate the disease by digging out diseased stools, using care to get out all the rhizome or underground portion of the plants. Such holes can be replanted since there is no evidence that infection is spread through the soil. The dividing line between fields to be ploughed up and those to be "rogued" must be determined by each individual grower, since it involves the economic side of the situation.

In planting the hardier canes should be used and whenever possible new varieties should be given a trial.

SUMMARY.

A serious epidemic of cane disease has been raging in Porto Rico for several years and continues unabated.

While various names have been applied to it, mottling disease is the preferred name.

The disease first appeared in the northwestern section of the Island (Arecibo-Aguadilla) and has spread rapidly eastward, until only a portion of the east and southeast coast regions remain uninfected. Indications point to continued progress of the disease. Upland fields have as a rule been the most severely attacked.

Losses to date are estimated at $2,500,000. Losses are produced by a reduction in tonnage. Difficulty is often experienced in handling the juice of diseased canes in the mill.

Observations and experimental plots demonstrate that the disease spreads by other means than infected seed pieces.

The mottling disease has been found on several varieties in Santo Domingo where is was not epidemic. One infection area has been reported from St. Croix.

The white (*Blanca*) or Otaheite was first seriously attacked, but in succeeding seasons the Rayada and other native types have succumbed. The numerous foreign varieties, mostly seedlings, vary greatly in their behavior, certain ones being very susceptible, while others give promise of proving satisfactorily resistant. Some of the station seedlings are promising.

The disease is characterized by a mottling of the leaves, followed in advanced stages by a stunting of the entire stool and the presence of gray, sunken lesions on the stalks. The appearance of the mottling varies greatly with the variety infected. Approximately a three-year course is followed, the disease becoming more pronounced with each succeeding ratoon, and ultimately causing death of the affected stools. No other hosts have been found.

A field to field survey has confirmed the opinion held that nature of the soil, years in cane, method of preparing the land, drainage, and other cultural factors have no direct relation.

Field and plant house observations and experiments demonstrated that fertilizers, liming, seed treatment, manner of disposing of the trash, soils, moisture content of soil, and all similar points have no direct influence. There is an accumulative effect in successive ratoon crops.

It has not been possible to transmit the disease artificially.

Chemical tests of the juice do not show any abnormal glucose ration or any constant difference between the juice or normal and diseased canes.

Fungi and bacteria are not associated in any way as causal agents, either on the leaves or stalks. The cankers are a result of

the general weakening of the plant, and are not primarily caused by fungi, which may, however, invade them later on in their development.

Planting tests of stalks showing leaves mottled in part only demonstrate that the infectious principle is present in all parts of diseased plants.

The disease is transmitted by means of diseased seed pieces, but has also some other means not yet apparent. It does not persist in the soil and infection is aerial. Certain insects are suspected as carriers.

The disease is considered to be an infectious chlorosis due to a virus or ultramicroscopic organism. The degeneration theory previously advanced is completely abandoned.

Lyon of Hawaii suggests that the yellow striping disease of Java and Hawaii is the same. There are many points of similarity, but lack of literature and authentic material of the yellow striping makes a final conclusion undesirable at this point.

Sereh is an infectious cane disease of Java which has been epidemic at times. It resembles mottling in some respects but is sufficiently distinct. The causes of the two diseases are thought to be of the same nature.

A comparison of symptoms, manner of transmission causes, and related points is made between mottling and the curly-top of beet, tobacco mosaic, spinach blight, peach yellows, cucumber mosaic, potato mosaic and other abnormalities of potatoes, all of which it is thought are due to similar causes, *i. e.*, ultramicroscopic organisms.

There are a number of diseases or abnormalities of cane which have been or might easily be confused with mottling. Deterioration is a phenomenon due to long continued cultivation of one variety, to poor cultivation, to unfavorable weather or other non-parasitic conditions. It is marked by a yellowing of the leaves and stunting of the stools.

There is a form of root disease due to the action of parasitic fungi which have not yet been clearly differentiated. Chlorosis is a yellowing or whitening of the leaves of entire stools in limited areas due to inability of the plants to assimilate sufficient iron in the presence of an excess of lime in the soil. Yellow spotting is characterized by spots on the leaves resembling those of mottling but more yellow in color. The condition is due to lack of cultivation or drouth.

Certain varieties of cane are subject to long white stripes on the leaves which are of the nature of chimeras. Under green-house

conditions mites produced markings on the leaves almost indistinguishable from those of mottling.

Sun burning and possibly surface-growing fungi produce gray blotches on exposed stalks.

A very serious epidemic of cane disease occurred in Porto Rico in 1872–80 and was studied by a royal commission without the cause being ascertained. In some respects it resembled the mottling but cannot be considered to have been that disease. It was controlled by natural factors and the use of resistant varieties. A later phase of the same situation was shown to be due to white grub attacks.

There have been minor epidemics, and one in particular of rind disease, but it has not been possible to trace any earlier occurrence of mottling, indicating that it is a recent introduction.

There have been serious outbreaks of cane disease in practically all other cane-growing regions of the world, including Java, Mauritius, and the West Indies. The mottling disease has no connection with either the rind (*Melanconium*) or gumming (*Bacterium vascularum*) diseases.

Control lies in the use of disease-free seed, and the elimination of diseased cane either by plowing badly attacked fields or by digging out diseased stools. United action on the part of all cane growers is necessary. The more resistant varieties should be used to the exclusion of the very susceptible types, and continued search made for varieties still more resistant or even immune.

LITERATURE CITED.

(1) Acosta, José Julián, Grand-Court, C. Grivot, y Stahl, Agustín.
1878. Informe dado a la Excelentísima Deputación Provincial Sobre la Enfermedad de la Caña de Azúcar en el 4°. Departamento de la Isla de Puerto Rico. Mayagüez.

(2) Allard, H. A.
1914. Mosaic Disease of Tobacco. U. S. Dep't Agric. Bull. 40.

(3) Anon.
1918. New Disease Causes Alarm. Facts About Sugar. Vol. 6, p. 426.

(4) Ball, E. D.
1917. The Beet Leafhopper and the Curly-Leaf Disease That it Transmits. Bibliography. Utah Agric. Exp. Sta. Bull. 155.

(5) BLAKE, MAURICE A.
1910. Peach Yellows and Little Peach. New Jersey Agric. Exp. Sta. Bull. 226, p. 1–26. 16 fig.

(6) CHAPMAN, G. H.
1917. Mosaic Disease of Tobacco. Mass. Agric. Exper. Sta. Bull. 175, p. 1–17.

(7) COLÓN, E. D.
1918. La Enfermedad de las Rayas Amarillas. Circ. 14, Insular Exp. Sta. P. R. 3 col. plates.

(8) COWGILL, H. B.
1919. Report of the Plant Breeder. *In* Report of the Insular Exp. Sta. P. R. 1917–18. (*In press.*)

(9) EARLE, F. S.
1918. Instrucciones para la Eradicación de la Enfermedad Mosaico de la Caña. Insular Exp. Sta. P. R. Circular 14.

(10) FAWCETT, GEORGE L.
1918. Una Enfermedad de la Caña Producida por Condiciones Desfavorables de Clima y Suelo. *In* Rev. Agric. e Ind. de Tucamán (Argentina), 1918.

(11) FERNÁNDEZ UMPIERRE, MANUEL.
1884. La Caña Dulce, o de Azúcar, y su Enfermedad en Puerto Rico. *In* Manual Práctico de la Agricultura de la Caña de Azúcar. San Juan.

(12) GILE, P. L.
1918. Chlorosis of Sugar Cane. *In* Report of the P. R. Agric. Exp. Sta. 1917, p. 10–19.

(13) HARRISON, J. B.
1912. Varieties of Sugar Cane. *In* West Indian Bull., vol. 13, no. 2, p. 177–217.

(14) HEIN, S. A. ARENDSEN.
1894. Gele Strepenziekte. *In* Archief voor de Java Suikerind., vol. 1, p. 215. 1 col. pl.

(15) JONSTON, J. R., and STEVENSON, JOHN A.
1917. Fungi and Diseases of Sugar Cane in Porto Rico. *In* Journ. of Dept. of Agric. of P. R. vol. 1, no. 4, pp. 177–251. 13 plates.

(16) KAMERLING, Z.
1900. Oenderzoekingen over Onvoidoenden Groei Ontifdiz Afsterven van rilt als gevolg van Wortelziekten. Medeel. van het Proefsta, vor Suik, en West-Java. No. 48.

(17) KAMERLING, Z.
1903. Verslag van het Wortel rot-Oenderzoek, Scerabaia.

(18) KRÜGER, W.
1899. Das Zuckerrohr und Scine Kultur. Chapter on Diseases, pp. 401–466, pls. 10–14, figs. 63–69. Magdeburg.

(19) LÓPEZ TUERO, FERNANDO.
1895. Enfermedad de la Caña de Azúcar. *In* Caña de Azúcar, pp. 105–123. San Juan.

(20) LYON, H. L.
1914. Lahaina Cane Injured by Yellow Striping. Hawaiian Planters' Record, vol. 10, pp. 320–323.

(21) McCLINTOCK, J. A., and SMITH, LOREN B.
1918. True Nature of Spinach-Blight and the Relation of Insects to its Transmission. *In* Journ. Agric. Res., vol. 14, no. 1, pp. 1–60. 12 pls., 1 col.

(22) NOWELL, W.
1917. Sugar-cane Disease in Porto Rico. *In* Agric. News of Barbados, vol. 16, no. 393, p. 158.

(23) ORTON, W. A.
1914. Potato Wilt, Leaf-Roll, and Related Diseases. Bull. No. 64, U. S. Dept. of Agric., pp. 1–16.

(24) PRINSEN-GEERLIGS, H. C.
1910. Epidemic Cane Diseases of Former Days. *In* Inter. Sugar Journ., vol. 12, no. 133, p. 23–26.

(25) SMITH, ERWIN F.
1914. Bacteria in Relation to Plant Diseases. Vol. 3, p. 3–38.

(26) STEVENSON, JOHN A.
1917. Report of the Pathologist. *In* Fifth Report of Bd. of Comm. of Agric. of P. R., p. 58–70.

(27) STEVENSON, JOHN A.
1917. La Enfermedad Nueva de la Caña. *In* La Revista Azucarera de P. R., vol. 2, nos. 24–25.

(28) STEVENSON, JOHN A.
1917. Cane Diseases in Porto Rico. *In* La. Planter, vol. 64, no. 5, p. 76–78.

(29) STEVENSON, JOHN A.
1917. Enfermedad de la Caña de Azúcar en Puerto Rico. *In* El Mundo Azucarero, vol. 5, no. 1, p. 19–24. Figs. 10.

(30) STEVENSON, JOHN A.
1917. La Nueva Enfermedad de la Caña. Insular Exp, Sta. of P, R. Circ. 11, p. 1–12.

(31) STEVENSON, JOHN A.
1917. Report of the Pathologist. *In* Ann. Report of the Insular Exp. Sta. of P. R. 1916–17, p. 37–77.

(32) STEVENSON, JOHN A.
1917. An Epiphytotic of Cane Disease in Porto Rico. *In* Phytopathology, vol. 7, no. 6, p. 418–425. 2 figs. Reprinted in the Hawaiian Plant. Rec. vol. 18, no. 4, p. 359–366.

(33) STEVENSON, JOHN A.
1918. La Enfermedad Nueva de la Caña. *In* Revista de Agric. de Puerto Rico, vol. 1, no. 1, p. 18–25. 2 figs.

(34) STEVENSON, JOHN A.
1918. Notas Sobre Medios de Combatir el Matizado de la Caña. *In* Revista de Agric. de P. R., vol. 2, no. 2, p. 11–12.

(35) STEWART, F. C.
1916. Observations on Some Degenerate Strain of Potatoes. Bull. 422, N. Y. Agric. Exper. Sta., p. 1–12.

(36) TEMPANY, H. A.
1909. The Passing of the Bourbon Cane in Antigua. *In* West Ind. Bull., vol. no. 1, p. 34–54.

(37) VAN MUSSCHENBROEK.
1892. Gele Strepenziekte. Circulaire no. 42 der Soerbaijasche Vereenig van 16 Oct. Bl. 327.

(38) WAKKER, J. H.
1894. Gele Strepsenziekte. Archief. voor de Java Suikrind., vol. 1, p. 4.

(39) WAKKER, J. H., and WENT, F. A. F. C.
1898. De Ziekten van het Suikerriet op Java. Leiden.

(40) WILBRINK, G. and LEDEBOER, F.
1910. Bijdrage tot de Kennis del Gele Strepenziekte. Mede deelingen van het Proefsta. voor de Java-Suikerind. no. 39, pp. 443–496. 5 pls. (4 col.)

(41) WORTLEY, E. J.
1915. The Transmission of Potato Mosaic Through the Tuber. *In* Sci. n. s., vol. 42, no. 1083, p. 460–1.

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THE YEAR'S EXPERIENCE WITH SUGAR-CANE MOSAIC OR YELLOW STRIPE DISEASE.

By F. S. EARLE.

In the JOURNAL OF THE DEPARTMENT OF AGRICULTURE AND LABOR for July 1919 (not published till January, 1920), Mr. J. A. Stevenson has given a summary of his studies on this disease, (for which he has proposed the name "Mottling"), made up to the time of his departure from Porto Rico in October, 1918. Active work has been in progress since that time on various lines connected with this investigation and it seems desirable at this time to make this report of further progress.

The present writer came to Porto Rico in August, 1918, commissioned by the United States Department of Agriculture to investigate this disease and with instructions to coöperate as fully as possible with both the Federal and Insular Experiment Stations and any other agencies or individuals engaged in any phase of its study After a preliminary inspection of the situation it seemed best to divide the problem into a number of projects in which the different workers could interest themselves, thus avoiding duplication of effort and also centering attention at first on those phases of the problem that seemed to promise the most immediate practical results. The following projects or divisions of the general problem were outlined and the effort was made to get work started in each of them: 1st. A field survey to determine the present extension of the disease. 2nd. Methods of eradication adapted to recent outbreaks or cases of partial infection. 3rd. Methods of cultivation best adapted to badly diseased fields. 4th. Statistics of sugar production as affected by the

disease. 5th. Methods of natural or artificial infection. 6th. Resistance and immunity—variety studies. 7th. An ecological survey of the insect inhabitants of the cane fields with special search for possible carriers of the disease. 8th. Cage experiments with insects suspected as disease carriers. 9th. Morphological, histological and cytological studies of diseased cane. 10th. Studies on the nature of the disease and search for a causal organism. 11th. Chemical studies of diseased as compared with healthy cane. 12th. Soil studies: Effects on the disease of different soils, soil sterilization, special fertilizers or other topical applications. 13th. Relationship with other similar diseases: A comparative study of the mosaic diseases.

In the following pages these topics will be taken up in order and the results so far obtained discussed.

1st. Field Survey—Present Distribution of the Disease.

The disease has now (November, 1919), been found in nearly all parts of Porto Rico.[1] The Yabucoa valley is the only well-marked region of the Island where at least occasional cases have not been found. This, however, does not necessarily indicate the rapid invasion of new territory. Several of the recently located outbreaks in eastern Porto Rico give clear evidence that the disease had been present for at least two or three years. The rapid spread of the disease from one part of the Island to another that is indicated by the various published reports concerning it will have to be accepted with some caution for it is evident that it has often been present in the fields for long periods without attracting attention. On the other hand certain regions, especially along the south coast, which were carefully inspected two years ago and found free from it are now quite heavily infected. For some unknown reason infection seems to have been much more active on the south west than on the north-east part of the Island.

While the disease thus occurs in practically all parts of the Island its distribution is by no means uniform. Along the north coast from Bayamón to Barceloneta it occurs on every plantation and practically in every cane field, but as yet infection is only partial, running from 1 or 2 per cent up to [illegible] or 60 per cent, and even considerably higher than this in some of the upland fields among the limestone hills. The fact so often noted by Stevenson still holds that the disease is much

[1] A few cases have also been found in the Island of Vieques

more abundant in these upland valleys than in the level lands near the sea. While the disease is now a commercial factor of importance in this district having caused very considerable losses in sugar yields during the past two years, there is still an abundance of healthy seed cane available, and as shown by the years experience at Central Carmen and Plazuela (see Bulletin 22) it is perfectly possible to control it at reasonable expense.

Farther west from Arecibo to Central Coloso below Aguadilla conditions are more serious. As shown by Mr. Figueroa's article on another page of this publication, yields of sugar have fallen off about 50 per cent in this district during the past three years. Even here, however, infection is not complete. With care good seed can still be selected from certain fields, and as shown by experience at Central Coloso (see Bull. 22) the disease can be controlled by methods of eradication if faithfully carried out. Cane planting has, however, been abandoned on large areas in this district, especially among the hills, as a consequence of the losses caused by this disease.

From Rincón around the west coast to San Germán infection is almost complete. Many fields are actually 100 per cent infected, the great majority are over 90 per cent diseased, and it is doubtful if any field can be found with as little as 50 per cent of sick cane. Much of the cane from this district goes to the big central at Guánica on the south coast, so that the published statistics do not fully show the facts in regard to sugar losses, but there can be no question that they have exceeded an average of 50 per cent. Most unfortunately, almost no healthy seed cane is available in this district. This will cause a still further falling off in the near future. The possibility of establishing seedbeds of healthy cane in this district has been discussed in another publication (Bulletin 22, pp. 15–16), where the opinion was expressed that though difficult this was not impossible. The suggestion was also made that for this district the planting of the resistant kinds discussed in Bulletin 19 might prove a more practical measure than attempts at eradication.

From San Germán eastward to Peñuelas the disease is also very prevalent. It has been spreading more rapidly during the past year in this district than in any other part of the Island, but there are still localities that have largely escaped so that some healthy seed cane is still available. The coast district near Guayanilla is as yet but little infected.

North of Ponce and in the neighborhood of Juana Díaz some

fields are badly diseased, but for the remainder of the south coast infection is still local and scattering and the disease can as yet hardly be said to have had any commercial effect.

The same may be said of the east coast and of the north coast east of Bayamón though severe local outbreaks occur at Trujillo Alto and in certain fields near Carolina.

Comparatively little cane is grown in the interior of the Island, but what there is is heavily infected as far east as Cayey. Outbreaks of importance also occur at Caguas and Juncos.

2ND. METHODS OF ERADICATION.

On arriving in Porto Rico last year scattered outbreaks of the disease were being reported in the eastern part of the Island in what was supposed to be clean territory. It seems obvious that such diseased plants should be at once destroyed to prevent further contagion without waiting for a more detailed study of the disease, and this advice was always given. In many cases it proved to be impossible to impress owners and managers with the gravity of the situation, but others responded immediately and did most effective work in cleaning up and dominating the disease. Secondary infection, the spread of the disease from infected to healthy plants, was often so active that at first it was feared that this method would not be effective in regions where infection was at all general, and it was only advised for isolated outbreaks. This method of controlling the disease was first suggested in print by Stevenson in the Spring of 1918 (REVISTA DE AGRICULTURA 1: 23, May, 1918). It had, however, been previously successfully practiced by Mr. Enrique Landrón, a cane grower in the hills back of Arecibo in a district where the disease was very active and destructive. It was also being followed with good results by Mr. José R. Aponte in the low lands of Arecibo near the Central Cambalache. Some eradication work had been done on the grounds of the Insular Station at Río Piedras, and Central Fajardo was carrying out a comprehensive eradication campaign. A study of these operations and continued field observations in all parts of the Island soon caused a change of view, and in November, 1918, Circular No. 14 was published strenuously advocating this method for controlling the disease in all parts of the Island, or at least in any region where healthy seed cane could still be secured. An active propaganda was undertaken among the cane planters in favor of this method and a considerable number of them

were induced to give it a trial on a large scale. The results obtained from this work during the first season have recently been gathered together and published as Bulletin No. 22 of the Insular Experiment Station, to which the reader is referred for fuller details. Only the summary need be quoted here which states: "1st, it is considered proven that the cane mosaic or yellow stripe disease can be controlled by the method of eradication discussed in Circular No. 14, in all regions where a supply of healthy seed can still be obtained; 2nd. in regions of complete infection the establishment of healthy seed fields is necessary before a campaign of eradication can be undertaken. This is difficult but not impossible. Failure at one time may be followed by success at another under apparently identical conditions." The method of eradication referred to in the above publications consists in, 1st, planting healthy seed that has been carefully selected while the leaves are still attached. Attempts at selection after the leaves are cut are useless. 2nd, in the frequent inspection of the fields while the cane is young to pull out such cases of disease as may occur either from overlooked diseased seed pieces or from secondary infection. Of the two operations the second is really the more important, for if some bad seed is planted it is quickly detected and removed by these inspections, but the best of seed planted in an infected district and not carefully inspected and "rogued" will inevitably become contaminated through secondary infection. Inspection should begin when the young cane has made its third leaf and should be repeated two or three times a month until the cane closes. It is useless to attempt eradication in large cane except in the case of fields which are to be cut for seed. If large cane becomes infected it is usually best to wait until after it is cut and then clean up the young ratoons which should be treated exactly like plant cane. It is necessary to dig out and replant the whole stool if any of the stalks show the disease.

While it is comparatively easy and inexpensive to reduce the percentage of disease by this method to a point where it ceases to be a commercial factor, it must be admitted that complete eradication is very difficult. It is altogether probable that seed selection and the inspection of young fields will have to be continued as part of the accepted routine of cane growing. Fields will have to be protected from this disease just as they are now protected from weeds and grasses. It is not to be expected that this disease will ever be banished from Puerto Rico.

3RD. METHODS OF CULTURE BEST ADAPTED TO BADLY DISEASED FIELDS.

The unexpectedly favorable results from eradication, and the finding of immune and resistant kinds (see Bulletin 19) have greatly reduced the supposed importance of this topic. It is obviously unwise to continue cultivating diseased fields of the ordinary varieties with certain loss of from 20 to 50 per cent of yield when such loss can be cheaply avoided by the methods of eradication or by the substitution of immune or resistant kinds. The fact remains, however, that in many districts the fields are now heavily diseased, and even if the above facts were universally accepted and acted upon, which, unfortunately is far from being the case, it would still take some years before the present conditions could be radically altered. Meanwhile what sugar is made will have to come from heavily diseased fields so, during this transition period at least, the best method of treating them becomes a question of great and immediate importance. It is indeed fortunate that this crisis in the sugar industry of western Porto Rico comes at a time of such phenomenally high prices. Otherwise losses would inevitably be very severe. Now even half the normal yield of sugar may show a profit or at least avoid a disastrous loss. Circular No. 17 (issued in Spanish) entitled "Recomendaciones sobre el Cultivo de la Caña en Puerto Rico," was largely written as a contribution to this problem. It was, however, a study of the cultivation problem in general and its underlying idea was to show that by using improved agricultural methods cane can be grown not only at a less cost per acre but with the greater yields secured at a still greater saving in the cost per ton. With the continued rise in the price of sugar the immediate problem with diseased fields is not so much how to reduce costs as how to increase yields even at the expense of a reasonable increase in cost. Luckily, enough data is at hand to show that cane even when fully attacked by the mosaic will respond to increased applications of fertilizers, especially the nitrogenous fertilizers. Under present conditions, therefore, cane growers in heavily infected districts should largely increase their application of fertilizers. Instead of using 2 bags per acre, which at present is a common practice, they should use 4 bags, and on top of this a bag of sulfate of ammonia, or in the dry season nitrate of soda. As an example of yields that have been obtained from heavily diseased cane an instance can be cited on the irrigated lands of the south coast when a 20 acre field of *gran cul-*

tura (long-season plant cane) of the susceptible B–3922 variety gave 51 tons per acre last year though it was estimated as 90 per cent diseased. The same field in previous years before the disease appeared and under the same cultivation had given an average of 65 tons. Fields of 4- and 5-year Rayada ratoons on the north coast which were from 90 to 95 per cent diseased, when well cultivated and fertilized as above, gave last year as high as 20 and 25 tons of cane per acre though the year before with ordinary care and fertilizing they had only given 5 to 10 tons per acre. This shows that much can be done to increase yeilds even in heavily diseased fields by better cultivation (by which is meant stirring the land with implements, not mere surface hoeing) and by the heavily increased use of nitrogenous fertilizers. Under existing conditions these methods are certainly justified. The pressing problem of the moment is to provide a sufficient supply of cane to keep the mills of western Porto Rico grinding for the next two or three years, for it will take that length of time to dominate the disease situation there by the best of efforts either in eradication or the planting of resistant kinds.

4TH. STATISTICS OF SUGAR PRODUCTION AS AFFECTED BY THE DISEASE.

On another page of this publication Mr. C. A. Figueroa, inspector of agriculture with the Insular Department of Agriculture, gives interesting statistics showing the tons of sugar produced at each of the mills on the Island during the past three crops and the corresponding number of acres of cane harvested. The losses in sugar in the different zones in which he divides the Island agrees so closely with the percentage of disease present as to leave no doubt that this has been the determining factor. It is unfortunate that rainfall tables were not available in sufficient detail so that they might have been included also, this being the only important factor in crop production that is omitted. The severe drouth of the Summer of 1918 unquestionably reduced sugar yields. Field notes show that in August and September cane was suffering badly for want of rain in all parts of the Island, excepting in the Río Piedras-Loíza district on the northeast and the Mayagüez district at the west. In both of these districts local showers prevented serious damage. In the first of these districts (corresponding to zone 9 of the tables), where the disease only exists in a few scattered localities, the crop of 1919 was larger than that of 1917 and only slightly smaller than that of 1918. In the fully diseased Mayagüez district the loss was 32.4 per cent in 1918 and 39.4 per cent in 1919. The south coast district

(zone 5) lost 10.8 per cent. This was all chargeable to the drouth and to unseasonable rains during the crop which lowered sucrose and purity. The Arecibo district (zone 2) on the north coast suffered about equally from drouth, but here where the disease was abundant the loss reached 39.7 per cent. In the Arecibo district proper with the Aguadilla district omitted, where rainfall was more abundant, the loss reaches nearly 50 per cent. The difference between the losses from these two regions can only be chargeable to the mosaic disease. We are safe in concluding in a general way that when infection reaches an average of 60 to 80 per cent losses of sugar will be from 30 to 40 per cent.

5TH. METHODS OF NATURAL OR ARTIFICIAL INFECTION.

One of the most remarkable things in the history of this disease is the fact that so many investigators in different parts of the world have studied it for years without suspecting its infectious nature. It has been known in Java since 1892, but as late as 1910 in the comprehensive paper by Wilbrink and Ledebour (Archief V. de Java Suikerindustrie 18: 464–518) it is considered as an abnormal bud variation. No literature is at hand which shows any change in this view on the part of the Java pathologists. This view was at first accepted also by Mr. S. L. Lyon in the Hawaiian Islands, though he seems to have been the first to suspect its real nature for he soon characterized it as "an infectious chlorosis." Stevenson took up the study of the disease independently in Porto Rico in 1915 without suspecting its identity with the "Gele Strepenziekte" of Java. In fact, in his latest paper (JOURNAL DEPARTMENT OF AGRICULTURE OF PORTO RICO 4:3, July 1919,) he does not accept this identity as proven. In his earlier papers he confused the symptoms of the yellow stripe disease with those of root disease. Later he clearly recognized that he was dealing with a distinct specific malady, but he explained it as caused by degeneration or abnormal variation It was not till the spring of 1918 (REVISTA DE AGRICULTURA DE PUERTO RICO 1: 18, May, 1918,) that he came to recognize it as an infection.

Secondary Infection.

It has from the first been recognized by all workers with this disease that it was hereditary, that cuttings from diseased stalks quite uniformly produced diseased plants. The rapid spread of the disease in Porto Rico indicated clearly that there must also be a

secondary infection by which the disease was communicated from diseased to healthy plants. In fact, a careful reading of the records of field experiments in the Java literature shows that this secondary infection was also present there, though for some reason it was not recognized. On arriving in Porto Rico careful attention was given to this phase of the subject and, as will be seen by the following extracts from field notes, it was not difficult to abundantly demonstrate its occurrence and its importance in spreading the disease.

Extracts from Field Notes on Secondary Infection.

"Los Caños, September 9, 1918.—A field of spring-planted Yellow Caledonia is very interesting. Evidently a few pieces of diseased seed were planted. The stools springing from these are much dwarfed and the leaves are all clearly infested from the ground up. In every case these stools were clearly foci of infection, as they were surrounded by a number of more recent cases in which the top leaves were infected while the bottom ones were healthy and where the growth of the plant was but little or not at all checked. In these secondary cases often only one stalk in a stool was affected."

This was the first case in which secondary infection was clearly differentiated from primary or seed infection. The effects of the disease on the Yellow Caledonia are very strongly marked and there could be no doubt as to the correct interpretation of the facts. The same conditions have since been observed in literally hundreds of fields in all parts of the Island.

"October 19, 1918.—The above field has gone from bad to worse. There are now many more cases than were observed last month. It is doubtful if over 5 per cent of the seed was infected but fully 30 per cent of the stools are now diseased."

"Los Caños, October 31, 1918.—The attempt was made to clean up part of a small triangular field of Yellow Caledonia plant cane near the mill in order to try some inoculation experiments. The cane was about 2 feet high. A little over 11 per cent of the seed was found to be diseased and was pulled up. About six weeks later (12–16–1918) 27 per cent of the stools were found to be diseased in the part of the field from which the diseased seed had been removed, while in the remainder of the field 67 per cent of the stools were diseased, the one "roguing" seeming to have reduced the number of cases by 40 per cent. These figures serve to show how rapidly the disease was spreading by secondary infection at this time."

"Los Caños, August 23, 1919.—A field of March-planted cane from carefully selected seed which came up healthy and remained so for some time now shows numerous infections on the side next a diseased ratoon field. Most of these cases are recent, the cane leaves being entirely normal up to six feet or more. This illustrates the fact that large cane may become diseased. It also shows that secondary infection has been much more active during the past two months than it was earlier in the season when the cane remained comparatively healthy though equally exposed to the disease."

"Central Cambalache, September 7, 1918.—A count in a certain field of *gran cultura* cane near the pump house showed 6 per cent infection. The cane was then about one foot high."

"December 16, 1918.—A count at the same spot showed 50 per cent of infection."

"Central Cambalache, August 22, 1919.—Numerous cases of recent secondary infection were observed in large cane six and 8 feet high."

"Central Coloso, January 2, 1919.—All fields in this district that are planted without seed selection are heavily infected with mosaic, mostly running from 75 per cent to 100 per cent diseased. For the past two years this *central* has been paying attention to seed selection. Fields planted with selected seed are showing an average of only 25 per cent to 30 per cent of disease. On one-half of a large field of *gran cultura* planted with selected seed they have tried pulling up diseased cane. It has now been gone over three times. At the first pulling 12 per cent of disease was found and removed. At the third pulling only 3 per cent of disease was found. The cost of such pulling was 45 cents to 50 cents per acre. At this time this part of the field is practically clean; almost no disease can be found. The other half of the field from which no diseased cane was pulled now shows fully 30 per cent disease."

"August 2, 1919.—Another inspection showed but little change in the above situation."

"Yauco, January 28, 1919.—Examined a field of young cane next to town which is now about three feet high. Secondary infection has evidently been very active. Judging from the present condition of diseased stools, less than 15 per cent of the seed was infected. Now 85 per cent of the stools are infected and many of the cases are evidently very recent."

"Yauco, April 10, 1919.—A field was observed here some time ago that had been planted by 'breaking banks' in a recently cut cane field but without destroying all of the old stubble. At the time of this first observation the seed cane had all germinated and was apparently all healthy. Considerable disease was, however, showing on ratoons from the old stubble between the rows. At this date many of the diseased ratoons are still growing and the plant cane now shows from 15 per cent to 20 per cent of disease clearly caused by secondary infection."

"Santa Rita, Guánica, December 31, 1918.—Mr. Bourne, who is in charge of experimental work here, has shown me a field of young B-3412 cane from which he pulled up 6 per cent of diseased plants a month ago. According to his count it now has 11 per cent of disease while an adjoining field of this kind planted at the same time from the same seed but from which no disease cane has been pulled now shows 25 per cent of disease. The 11 per cent in the one case and the 19 per cent in the other evidently represented secondary infections."

The immunity experiment conducted at Santa Rita, Guánica, which has been fully reported in Insular Experiment Station Bulletin 19, gave one of the most convincing proofs of secondary infection. Thirty healthy seeds of each of 90 varieties were planted in early October, 1918. Every third row was planted with diseas-

Rayada so that each kind was uniformly and completely exposed to infection. By December 31st all of these kinds excepting the immune Kavangire had developed from 50 to 100 per cent of disease. No more conclusive proof of infection than this could be possible.

The Means by Which Infection is Carried from One Cane to Another.

While nothing can be more certain than that this is an infectious disease, that the contagion is carried from sick plants to healthy ones, we so far knew nothing as to the means by which this is accomplished. On reading Stevenson's article on this disease published in *Phytopathology* (7:418–425, 1917), the idea at once occurred to the present writer that an insect carrier was involved, as is the case with some of the other mosaic diseases and with the Curley Top of the beet. A letter was written to Mr. Stevenson making the suggestion and asking if he had any field observations that would support it. Since coming to Porto Rico this question has been constantly in mind as it is of great practical importance. At times field observations have been made that seem to strongly support this hypothesis. For instance, at the Santa Rita immunity experiment when the disease was running so rapidly in December there was an unusual abundance of leaf hoppers of several species. They literally rose in swarms when walking through the young cane. Later when the disease had become so much less active the leaf hoppers had practically disappeared. Very few of them could be found. The aid of the entomologists was early invoked for help in the solution of this problem. Extensive cage experiments were tried with a considerable number of cane insects both here and at the Federal Station at Mayagüez. Professor Smyth gives an account of his work here in another part of this publication. The Mayagüez experiments will be reported in the Annual Report of that Station. Only 4 takes were secured by Professor Smyth out of 185 experiments. Under other conditions this might be accepted as proof that insects do sometimes carry the disease, but as the chance for accidental infection is always present in Porto Rico so small a percentage of takes can not be considered as conclusive. Professor Tower of the Federal Station reports no takes at all as the result of his experiments. The case therefore still stands as not proven.

The belief, however, remains that insect carriers of some kind are responsible for the spread of the disease. This would completely account for all of the observed facts and no other suggestion has been made that can do so.

To What Distance can the Contagion be Carried in Cases of Secondary Infection?

In the field at Los Caños, where secondary infection was first clearly observed, the secondary cases were all clustered quite closely about the primary cases of seed-infected stools. In fact, most of them were in immediately adjoining stools. This seems to be the normal method of spreading, from an infected hill to those nearest to it. Instances have frequently been noted where a roadway or an irrigation ditch has acted as a fairly efficient but never as a complete barrier. Just east of the town of Bayamón there is a strip of pasture land with no cane fields for a width of perhaps half a mile. This has served as a barrier and has for three years prevented the disease from passing eastward.

On the other hand the disease is constantly appearing in new districts and at times under circumstances that make it highly improbable that diseased seed cane had been introduced. Of course in most cases new outbreaks are easily traced to diseased seed. At Central Fajardo at least two instances have been noted where a few isolated cases have been discovered in fields far removed from any other diseased cane and where no contaminated seed could possibly be traced. At Central Aguirre, too, a number of such scattered diseased stools have been found at points far distant from any known source of infection. As an instance, four diseased stools were found near together in the middle of a field near the mill. At that time no other diseased cane had been found within a number of miles of this place. A careful search of the field from which this seed cane came failed to show any sign of disease. While secondary infection thus usually takes place between diseased canes and those immediately adjoining it seems clear that at times the infection may be carried for very considerable distances.

Periodicity or Irregularity of Secondary Infection in the Same Locality.

It is a matter of common observation that at some times this disease spreads much faster that at others. Popular opinion seems to be that the spread is fastest in late summer and fall and less active in the spring. Such observations as have been recorded tend to confirm this view, but it is by no means proven that there is any such periodicity in the irregularity of infection. The point needs further study since it might have an important bearing on the time for attempting to establish seed fields in infected territory.

In August it was noted at both Cambalache and Los Caños near Arecibo that secondary infection had recently become quite active

in spring-planted fields that had largely escaped contagion earlier in the season.

The most remarkable instances of irregularity in the spread of the contagion is that recorded in Insular Experiment Station Bulletin 19 on the immunity experiment at Santa Rita. Healthy seed planted in early October was quite fully infected by the end of December, showing unprecedented activity in infection. That planted early in December never became over half infected, nine of the varieties escaping entirely, while that planted the last of December had in April only developed 6 and 8 per cent of disease. It must be remarked that this last was not interplanted with diseased cane like the others, but on the side adjoining diseased old cane it had only developed 8 per cent of disease, showing a most remarkable falling off in virulency from the condition in the same field in November and December.

Difference in the Activity of Secondary Infection in Different Localities.

Since this disease first attracted attention in Porto Rico a marked difference has been noted in its behavior in different localities. Stevenson in his various reports has frequently called attention to the fact that it always seems to spread faster among the hills of the interior than in the open level lands near the sea. That this condition still prevails has been confirmed by hundreds of observations made during the past year. At least for the whole extent of the north coast it is rare to find a field near the sea that is heavily infected, but back in the valleys among the limestone hills it is equally rare to find one that is not so infected. Even when the seed infection has been about the same the disease has spread much more rapidly among the hills. This is not so marked on the west coast, where practically all of the fields are now heavily infected.

In a general way the spread of the disease by secondary infection has been much more rapid and alarming in the territory west of a line drawn from Arecibo or Barceloneta to Ponce than it has been at any point east of that line. No cases have been observed in eastern Porto Rico where entire fields have been quickly involved, as happened at the Santa Rita immunity experiment and in the attempted seed field plantings at Los Caños and Florida. Secondary infection has occurred in all districts, but in the eastern part it has involved comparatively few plants at any one time.

It is a curious fact that in the propagating house at the Insular Experiment Station no secondary cases were observed for many

months, although healthy and diseased plants were growing side by side for three years. It is only during the last six months that a few such cases have appeared. In some cases diseased and healthy cuttings were planted in the same pot and grew with their roots and leaves intermingled for over a year with no transmission of the disease taking place. Again, diseased and healthy plants have been grown in the same wire netting cage in the open grounds with no development of secondary cases even when the cage was heavily colonized by sucking insects.[1]

When the method of natural infection is once learned these facts can doubtless be easily explained, but at present no theory can be offered that will account for them.

Artificial Inoculations.

The different mosaic diseases which have been investigated present very marked differences in the ease with which they may be produced artificially. At the time that these investigations were begun, (August, 1918,) only one successful inoculation experiment had been reported with the cane mosaic or yellow stripe disease, that by Dr. Kamerling in Java in 1902.[1] Later investigators in Java had been unable to corroborate this result since, according to Wilbrink and Ledeboer,[2] all subsequent attempts at inoculations had failed. Stevenson, too, in his various papers on this disease reports only failures in his attempts at inoculation. Since inoculations with diseased cane juice had given such unsatisfactory results the attempt was made to try out other methods by which the disease might be conveyed, the results of which are given in the notes on the following 21 experiments. It will be noted that three of these experiments, Nos. 1, 2 and 12, consisted in rubbing or otherwise lacerating healthy leaves with diseased tissue which is the successful method for conveying the bean mosaic. No cases resulted. Experiments 3, 5, 10 and 11 consisted in binding pieces of diseased tissue in contact with cut surfaces of healthy stalks. Out of 11 such attempts one was successful (see No. 5). In experiments 4, 6 and 8 bits of diseased tissue were dropped into the inrolled terminal leaf spindle so as to lie in contact with unwounded young tissue. Out of 60 attempts four positive cases resulted. In experiment No. 6, three out of five attempts were successful, the highest proportion in any of these experiments, yet the same method used on a large scale at Arecibo (No. 8)

[1] Since the above was written secondary infection has developed in some of these cases.
[1] Am. Rept. Kagok Proefstation, Java, 1902.
[2] Med. Het Proefstation, Java, 1910.

completely failed. In experiment No. 7 a hypodermic needle was thrust into the soft tissue near the terminal bud of a diseased cane and was immediately inserted near the base of the inrolled leaf spindle. There was no result from 50 attempts. Experiment No. 9 was the only one made with diseased juice exposed in the open air. It was intended as a check on the following experiments, no positive results being expected on account of the failure of this method that had been so often reported. As a matter of fact two out of seven attempts developed good cases, the one in a little over three weeks, the other in between four and six weeks.

Since the disease was spreading rapidly in the fields by secondary infection and since insect carriers seemed to be the only logical explanation of this spread the attempt was made to visualize any possible differences in method between this hypothethical inoculation by insects and the previous attempts at artificial inoculation. Since young cane tissue, and to a less extent cane juice turns brown quickly when exposed to the air it seemed possible that this oxidation might affect the vitality of the mosaic virus, and that a sucking insect flying from a diseased to a healthy plant and again feeding might regurgitate a minute quantity of the diseased juice without having exposed it to the air. To test this idea the attempt was made to extract juice from diseased cane under oil to avoid exposing it to the air. In experiments 13 and 14 the technique was faulty, still one case developed in No. 4 after only two weeks incubation. In experiment 15 a satisfactory juice was obtained which remained clear and absolutely colorless under the protective oil covering. Of the ten inoculations in this experiment five developed typical cases of disease within a few weeks' time, and the basal suckers also showed the disease, demonstrating the fact that the entire plant had become infected. However, experiments 20 and 21 which were designed to exactly duplicate this one gave no positive cases.

Experiments 17, 18 and 19 are sufficiently explained by the notes under each. The peculiar differences in behavior of the inoculated plants in 18 and 19 can only be explained on the supposition that the virus from the diseased bits of tissue in the test tubes had propagated in the protected healthy juice and that it produced local lesions in the leaves of the plants into which it was injected even though no cases of disease were induced. The same effect was observed to a marked degree in experiment 20 and to a less extent at various other times. These observations seem to indicate that the virus may cause

temporary local lesions even when the disease does not become generalized so as to affect the entire plant.

The prompt production of diseased suckers from the base of infected stalk shows that the entire stalk must become diseased at about the time that it first becomes evident in the terminal leaves. The leaves formed before this time, however, do not show the disease but remain normal in color until they dry up. Secondary infections in the field can usually be distinguished from seed infection, for in the latter all the leaves will be affected and the growth usually stunted while in the former the basal leaves remain normal and for a time at least growth is but little checked. Then, too, in seed infection all the stalks in the stools are involved; in secondary infection at first only one or a part of the stalks show the disease. After cutting the cane all of the ratoon sprouts from an infected stool will show the disease; that is, all of those having organic connection through the old stubble. Without this organic connection two plants, one healthy and the other diseased, may grow in close contact with their roots intermingled for months or even for years without any transference of the disease.

In interpreting the above results it must be borne in mind that in practically all parts of Porto Rico there is more or less danger of natural infection. The results of all inoculation experiments made here must always be subject to more or less doubt from this cause. As a matter of fact two natural cases appeared in that part of field No. 11 where most of these experiments were made, and several others occurred in other parts of this field. In the experiments in this field where inoculations with diseased juice or diseased tissue were made in 54 stalks, 12 of them developed the disease. Several hundred stalks were included in the area where only two cases developed from natural infection. This proportion is so much smaller that we are forced to conclude that at least a portion of these 12 cases were caused by artificial inoculations. The fact remains, however, that the successes were much less frequent than the failures, that the best results could not always be duplicated, and that the successful transfer of the disease is dependent on some factor or factors as yet absolutely undiscovered.

Inoculation Experiments.

September 12, 1918.—Insular Experiment Station greenhouse, cane plants in pots.

1. Five stalks. Young leaves rubbed vigorously with diseased leaf (as in method of conveying bean mosaic). No results.

2. Five stalks. Young leaves rubbed with tissue from near the tip of diseased stalk. No results.
3. Four stalks. Cut with slanting cut and wedge of diseased tissue inserted. No results.
4. Five stalks with bits of diseased tissue dropped into the inrolled leaf spindle of terminal bud.

   On October 21 one plant in this lot was showing symptoms of mosaic and by October 26 it was a clearly developed case.

January 12, 1919.—Insular Station field No. 11, Yellow Caledonia ratoons.

5. Two stalks. Made slanting cut on side and pushed in a wedge-shaped "graft" made from the tip of a diseased cane, covered with waxed paper and tied firmly.
6. Five stalks. Dropped bits of diseased tissue in inrolled leaf cylinder of terminal bud.

   On January 31 one of the "grafts" in experiment 5 was still alive the other was dead.

   February 27, 1919. One of the stalks in lot 5 had developed a good case. The other remained negative.

   February 11. One of the plants in lot 6 show the disease.

   March 13. Two more plants in lot 6 have developed the disease and the first one shows diseased suckers at the base. The other two plants remained negative.

October 31, 1918.—Central Los Caños, Arecibo. Plant cane of Yellow Caledonia, stalks about 2 feet high.

7. Fifty stalks inoculated with needle punctures through the inrolled leaf spindle just above the terminal bud. The hypodermic needle was first thrust into the soft tissue near the tip of a diseased cane and then into the stalk to be inoculated.
8. Fifty stalks. Diseased tissue dropped into the inrolled leaf spindle.

Two or three cases of mosaic developed in each of these lots but as natural secondary infection was active fully as many cases developed in the adjoining untreated rows. The result was thereafter negative.

January 31, 1919.—Insular Station field No. 11. Yellow Caledonia ratoons.

9. Inoculated 7 canes (about 2 feet high) with hypodermic

needle, using juice from diseased cane pressed out by hand laboratory mill. The needle was thrust into the leaf spindle above terminal bud.

Februar 23, 1919. One of these cane has developed mosaic.

March 11, 1919. One more case has just developed the disease. The remaining 5 stalks remained negative.

January 20, 1919. Insular Station greenhouse.

10. "Inarched" a diseased and a health cane (both growing in pots) by cutting away about one-third of each cane for a distance of 3 inches and binding the exposed surfaces together.

 The canes lived for some months but the healthy cane did not contract the disease.

January 31, 1919.—Insular Station Field 5. Spring plant cane about 7 feet high with well-developed stalks, variety P. R.-271.

11. Prepared 4 stalks by cutting out a block of cane one inch long and one-quarter to one-third inch thick with a bud in center. The space was filled with a similar block with bud in center cut from a diseased cane which was firmly tied in place and well covered with waxed paper.

 These diseased blocks remained alive for some weeks but no cases resulted.

January 31, 1919.—Same field as above.

12. Two canes inoculated by placing a diseased leaf in contact with a healthy one and boring the point of a penknife through the two leaves so as to blend the tissues. No results.

January 31, 1919.—Insular Station. Field 11. Yellow Caledonia ratoons.

Since freshly cut cane tissue and cane juice oxidizes quickly with change of color when exposed to the air it was thought that this oxidation might destroy the contagion. The attempt was made to protect the juice from air by crushing pieces of cane in a morter which was partially filled with olive oil. It was difficult to get out the juice in this way and it seemed to emulsify to some extent with the oil.

13. Ten stalks were inoculated with the mixed oil and juice.

 On February 8 these plants showed extensive yellow

oil-soaked areas both above and below the needle pricks. These shaded out into mottled areas and stripes looking much like incipient cases of the disease. Some of these stalks finally died from the effect of the oil but none of them developed mosaic.

February 1, 1919.—Insular Station Field 11. Yellow Caledonia ratoons.

14. Ten more stalks were inoculated with juice pressed out under gas-engine cylinder oil in a mortar. This did not emulsify but so little juice was secured that water was added in order to suck it into the needle without oil.

    February 15. One typical case had developed and was photographed. The other nine remained negative.

15. February 8, 1919. Prepared juice from diseased cane without exposure to air by taking bits of the cane in strong pincers and holding them under gas-engine cylinder oil in a beaker while pressing out the juice.

    Inoculated 10 canes about 2 feet high, Yellow Caledonia ratoons, field 11, with this juice by inserting the hypodermic needle into the leaf spindle just above the terminal bud.

    Also inoculated 7 canes in same field by inserting the needle into the midrib of young leaves. These last gave only negative results.

    March 7. Five of the ten canes inoculated in the leaf spindle on February 8 now show pronounced cases of mosaic. In three of them basal suckers are also showing the disease thus demonstrating that the entire plant quickly becomes infected.

16. February 9, 1919. With the oil protected juice prepared yesterday 3 inoculations were made in the leaf spindle of terminal bud in spring-planted P. R.-271 cane 6 feet high in field 5 C. When the new leaves developed conspicuous yellowish areas appeared both above and below the needle pricks. For some time they were regarded as incipient cases but these symptoms finally faded out and no infection followed.

17. February 12, 1919. In order to test the possibility of propagating the mosaic infection outside of the cane plant, juice from healthy cane was expressed under cylinder oil to protect it from oxidation. This juice was pipetted to test

tubes in which half an inch of oil had been placed and thus protected from contacted with the air the tubes were sterilized in the autoclave. When cool bits of tissue cut with flamed scalpel from near the growing point of diseased cane were forced under the oil in one series of tubes and corresponding pieces of tissue from healthy cane were placed in another series as checks.

The juice remained bright and clear in both series for many weeks, the only difference noted being that the bits of healthy tissue mostly sank to the bottom of the tubes while most of the bits of diseased tissue floated between the juice and the oil.

18. March 9, 1919. Inoculated 10 canes in the Yellow Caledonia ratoons, field 11, with juice from one of the tubes prepared on February 12 in which a bit of diseased cane was suspended and 10 more from one of the check tubes
19. which contained a bit of healthy tissue.

On March 15 it was noted that a number of the plants in the first series were showing local discoloration near the needle punctures but that no such discoloration could be noted in the check series.

On March 26 trifling local discoloration was noted in two plants in the checks series the remaining 8 showing only dried-down needle pricks. Five of the ten in the first series, on the contrary, showed mottled discolored areas three or four inches in extent about the needle pricks and they were noted as incipient cases. Three of the plants showed slight local discoloration only, while the other two were intermediate, but it was thought at the time that they would develop good cases. As a matter of fact, after being visible for some weeks the color finally faded out from all of these areas and no cases resulted in either series, but there can be no question as to their different behavior.

March 21, 1919.—Caledonia Ratoons, field 11.

20. Inoculated 10 canes with oil-protected juice from diseased cane (prepared as on February 8) injected into leaf spindle just above the terminal bud.

On March 29, it was noted that nine of the above inoculations showed pronounced local discolorations in the neighborhood of the needle pricks. These discolored areas

presented much the appearance of the true mosaic and in some cases they could be traced for three or four inches above and below the needle pricks. As the successful inoculations made in this same manner on February 8 had also shown these preliminary symptoms it was confidently expected that nine positive cases would result. However, after remaining visible for some weeks the discolorations finally faded out and no infections followed.

21. March 21, 1919. Six inoculations were also made with the same oil-protected juice in young ratoons in pots in the greenhouse. No cases resulted.

The results of inoculation experiments made at this station by the pathologist, Mr. Julius Matz, will be found on another page. He also had only occasional successes in communicating the disease. Details of the cage experiments with insects suspected as being carriers of the disease are given by the entomologist of the Station, Mr. E. G. Smyth, at another place in this publication. The verdict here will simply have to be "not proven."

The situation under this heading may be summarized as follows:

1st. Sugar-cane mosaic is hereditary, being uniformly carried in diseased cuttings and always appearing in plants grown from them.

2nd. Secondary infection exists in nature and is often responsible for the rapid spread of the disease to previously healthy cane. Ordinarily it is nearby stools that are thus affected, but occasionally the disease seems to be carried for long distances. Secondary infection is more active in some localities than in others. It is also more active at some times than at others in the same locality. Insect carriers of the disease have been suspected, but so far this is not proven.

3rd. Successful artificial transfers of the disease have been made by various methods but the results have not been uniform and complete failure often results.

6TH. RESISTANCE AND IMMUNITY—VARIETY STUDIES.

The importance of this topic was early recognized and field observations were made on the behavior of the varieties to the disease at all opportunities. A few notes on the supposed resistance of certain kinds had been published by Stevenson and by Cowgill. It was, however, the finding of an apparently immune variety, the Japanese[1] Kavangire, in the experimental plots at the Federal Station

[1] Since the above was written the publication of a paper on this variety by Dr. Cross of the Argentine Station at Tucuman shows that this is a north Indian cane but that it has never been cultivated in Japan.

at Mayagüez, that focussed attention on this phase of the problem and indicated the necessity for an immediate comprehensive study of varietal resistance. Evidently plots for this purpose would have to be located in a diseased district and would have to be so planted as to subject each kind to an equal chance for infection. It was at first proposed to the Federal Station at Mayagüez that they make such a planting. No land for the purpose being available, however, an arrangement was made with the Central Guánica for putting in such an experiment at their trial grounds at Santa Rita under the supervision of Mr. Bourne, who was then in charge of their experimental work. A total of 171 kinds were planted in rows of 30 seed pieces each and every third row was planted with diseased Rayada in order to secure a uniform chance for infection. The results of this experiment were published in Insular Station Bulletin 19, where full details are given. They may be summarized by saying that the full immunity of the Kavangire cane was proven. Convincing proof of periodicity or irregularity in the activity of the infection was secured. From this cause 9 of the kinds failed to become infected. Of the remainder 40 varieties were clearly more susceptible than the Rayada; that is, they showed greater injury when attacked by the disease; 42 kinds were listed as about equal to Rayada in this respect; while 73 kinds made a somewhat better showing than the Rayada. The bulletin, however, fails to call attention to the fact that the Rayada rows are all from infected seed and that this constitutes a heavy handicap in comparing them with the other kinds, which were all secondary infections. If the experiment is continued another year the Rayada will make a decidedly better showing in the ratoon crop, which will practically all come from infected stubble. Of these 73 kinds 24 were listed as being especially resistant, or perhaps the better word would be tolerant, to the disease since, though fully infected, their growth was but little affected. Of these the best in order named were given as Java 56, Java 234, and G. C.–1313 (Guánica Central seedling). The name of the first-mentioned and most promising of these kinds needs a further word of explanation. In a footnote on page 6, Bulletin 19, the statement is made that "this is the J.–36 of the Argentine but is not the true J.–36 of Java." This was said because of the description by Noel Deerr (Cane Sugar, p. 41) of Java 36 (P. O. J.) which calls for a green cane. The finding of the very full description of this variety by Jesweit (Med. V. Proefs. V. Java-Sukerindustrie Series 1917 (No. 12, p. 6) shows conclusively that this is our cane and that its name is Java 36

Java. It is one of Kobus' seedlings having the North India variety (P. O. J.), the initials standing for words meaning Proofstation East Chunnee as staminate parent and the Black Cheribon (Louisiana Purple) as pistilate parent. The description of the green variety quoted by Deerr properly belongs to Java 36 (Bouricius), a cane belonging in a different series of seedlings and from different parentage. The careless use of the initial J. to indicate any seedling cane from Java is an error, since several numbered series of seedling canes have been produced in Java. "J–228" and "J–234" of Bulletin 19 should also be written J–228 (P. O. J.) and J–234 (P. O. J.), since they, too, are seedlings by Kobus from the same parentage. The resistance of these kinds clearly comes from the North Indian ancestry. The Japanese varieties also all came originally from northern India. Observations on another Japanese cane, the Zwinga or so-called "fodder cane" of the southern States, indicate that it, too, is immune to the mosaic, though it has not been subjected to such convincing tests as the Kavangire, which it closely resembles but from which it may be easily distinguished.

7TH. ECOLOGICAL SURVEY OF THE INSECTS INHABITANTS OF CANE FIELDS.

The importance of this topic was based on the supposed existence of some insect carrier for the mosaic disease. Field observations on cane insects have been made wherever possible and many scattered notes have been made, but the personel has been lacking for a comprehensive study of this subject. The paper on cane insects on another page by Mr. Smyth brings out many new facts and serves as an important contribution to the subject. It is indeed remarkable that the minute spring tail, which is so exceedingly common on cane leaves and which is responsible for so much of the minute spotting which is often confused with the mosaic, should never before have been recorded as a cane pest. This emphasizes the need for work in this interesting field aside from the chance discovery of a carrier for the mosaic.

8TH. CAGE EXPERIMENTS WITH INSECTS SUSPECTED AS DISEASE CARRIERS.

Much painstaking work was done on this topic both here at the Insular Station by Mr. Smyth and at the Federal Station at Mayagüez by Mr. W. V. Tower. The details of part of this work appears on other pages of this publication. Very unexpectedly, no results

at all were secured at Mayagüez and the cases of disease following colonization with insects here were so few as to be within the possibility of accidental or natural infection. The case therefore is not proven. This, however, does not preclude the possibility that an insect carrier or insect carriers exist. In fact, this hypothesis is the only one so far suggested that will account for the observed facts in the spread of the disease.

9TH. MORPHOLOGICAL, HISTOLOGICAL AND CYTOLOGICAL STUDIES OF DISEASED AS COMPARED WITH HEALTHY CANE.

A reading of the literature of this disease is sufficiently convincing that this subject is in need of study. The statement is found that infected leaves contain less chlorophyll than normal ones, but it is not clear whether this is because less is being elaborated by the chromatophores, as in etiolation from shade, or whether these bodies themselves are lacking. In discussing the stem cankers Stevenson says (Ann. Rept. 1917, p. 47):

> "Penetration of the tissues is never very deep, hardly more than from one to two millimeters at first, and is often limited to a few layers of cells only. The affected tissues are red, but not different in shade or other characteristics from similar effects produced by other causes. There are no other internal symptoms except as noted below."

In the paragraph to which this last remark seems to refer he adds:

> "In addition to the stunting or dwarfing of the stools there is a shrinking of the internodes of the individual stalks. This is especially pronounced in what might be determined third-phase cases or those in the last stages of the disease. Such stalks are almost completely lacking in juice, the limited amount of pith tissue formed being of a rubbery consistency."

This practically completes our previous knowledge of conditions within the diseased plants, so that the paper by Mr. Matz on another page of this issue constitutes a decidedly new contribution. The present writer has followed Mr. Matz's work with great interest and has seen his preparations. While the study is a preliminary one and no sweeping deductions are as yet to be drawn from it, the interesting fact remains that certain cells or groups of cells in the parenchyma of diseased stalks are filled with a peculiar granular protoplasmic substance. These plugged cells can be detected in very young tissues. They may occur at any point within the center of the stalk, and are also found in the leaves and leaf sheaths. The

cankers are formed by the final breaking down of these abnormal areas. A somewhat similar condition has occasionally been found in injured discolored tissues of canes that were free from the mosaic disease, but this abnormal condition can be distinguished from the one under discussion. These groups of abnormally filled cells at least furnish a physical basis for the disease, and that is something which has heretofore been lacking. The appearance of the abnormal material filling these cells is so much like that of a plasmodium that eager search was made for some indication of swarm spores or other fruiting bodies, but for a long time without result, the only change noted being that in the older tissues the granular appearance of the plasma became more marked as though it were becoming multinucleate. At length in an old cankered stalk that had become partially dried by lying two or three weeks in the laboratory it was observed that the entire plasmodium had broken up into minute, irregular, rod-shaped bodies, some of which showed X and Y forms. These minute rods were motile, revolving slowly on their axes so that the whole mass was clearly agitated but there was little active movement of translation. Taken alone, these bodies would unquestionably be called bacteria, but ordinary bacteria are not formed from a plasmodium that exists in that form for weeks and months. A similarity to the parasitic genus *Plasmodiophora* among the slime moulds is clearly suggested, but these motile bacteria-like bodies are very different from the regular globose spores of that genus. Perhaps the nearest parallel is furnished by the nodule-forming organism of the *Leguminosæ*, where the first stage is a zoogloea mass within the young root cells, but this very early breaks up into the irregular rods that in shape and behavior closely resemble those of the organism under discussion. For the present it seems best to withhold any positive statement as to its true systematic position. No causal relationship with the mosaic disease has as yet been proven, but at least the presence of this peculiar organism seems to serve as a diagnostic character of importance and one that has heretofore been overlooked.

10TH. STUDIES ON THE NATURE OF THE DISEASE AND SEARCH FOR A CASUAL ORGANISM.

The close relation of this topic to the last one is easily recognized. The nature of the disease has also been discussed in the paragraphs on natural and artificial infection where we have seen how persistently it has been regarded as a degeneration, bud variation or

abnormality. Nothing can be more clearly proven than that it is an infection, so these earlier views now have only an historical interest.

The proper name to be applied to this disease demands a moment's discussion. The Dutch investigators in Java have called it "Gele Strepenziekte," or as literally translated by Hawaiian writers, "Yellow Stripe Disease."[1] This is clearly the earliest name applied to it in scientific literature and if priority is insisted on it must be recognized. Unfortunately, it is misleading since in the great majority of cases no striping effect is produced. Stevenson's name of "Mottling disease" is much more truly descriptive. In its Spanish form, "Matizado" it has come to be the universally recognized term for it in Porto Rico. The present writer is responsible for adding still another name, "Sugar-Cane Mosaic" (Insular Station Circular 14:6), but he has always used it as a descriptive phrase in connection with one or both of the other names, intending by so doing to convey some idea of its general nature and relationship. The mosaic diseases are an obscure class of poorly understood disorders on which there has come to be a considerable literature. While there are well-marked differences among them they seem to have much in common. Whichever term we may prefer as the specific name of this cane sickness the fact will remain that to the best of our present knowledge it is a mosaic disease.

The real nature of this class of disorders has been the subject of much discussion. Very divergent views have been held regarding them and it must be admitted that even at the present day pathologists are by no means in full accord regarding them. A few years ago it was the fashion to ascribe them to an abnormal secretion of enzymes produced in some inscrutible manner by a change in the internal functions of the plant. They were considered functional diseases. It is easy to understand that sudden changes in environmental conditions might induce functional disorders. It is well known, in fact, that this is the case. Many such invironmental diseases are known but none of them are contagious. No satisfactory explanation has ever been given of how a disease may be conveyed from a sick plant to a healthy one except by means of living parasitic organisms. The advocates of the above theory have therefore always sought to minimize the evidence of infection and to account for the

[1] Stevenson even in his latest paper, *Journ. Dept. Agric. of Porto Rico,* III (No. 8), July 19, is unwilling to admit that the identity of this with the Porto Rican disease is proven The fact that so many outbreaks in different parts of the world can be traced to importations of Java seed cane together with the internal evidence from the descriptions and illustrations in the Java literature leaves no possible doubt in the mind of the present writer that Lyon is absolutely correct in considering them as identical.

spread of these diseases on the ground of inherited predisposition or, in other words, by degeneration and abnormal bud variation. As we have seen in the foregoing pages, the evidence of the infectious ness of this cane disease is overwhelming. It is equally convincing in regard to all of the other mosaics that have been studied. Recently this has lead to the rather wide acceptance of the idea that they are caused by ultramicroscopic parasites—the hypothesis held to-day by human pathologists to account for contagious diseases such as smallpox and various others, for which no parasites have yet been discovered. It is certainly true that no ordinary bacteria or fungus hyphae can be found in the diseased cane tissues except those that are clearly secondary in very old cankers, and no such organisms can be cultivated from them by ordinary laboratory methods. It can be safely affirmed that the mosaic diseases are not caused by ordinary bacteria nor by filamentous fungi. Of course, we know that chemical atoms and molecules are far too small to be visible under the microscope. There is nothing impossible in the conception of living bodies so small, that like the atoms and molecules we can only know them by their effects. On the other hand, we may have the alternate conception of a naked-celled amoeboid parasite not so small but so similar in structure to the other protoplasmic contents of the plant cells that it has so far escaped detection. A living virus seems to be necessary in order to account for the spread of infectious diseases. When we cannot demonstrate one we are forced to imagine one. It is not yet proven, that the plasmodium-forming organism referred to under the last heading as having been uniformly found by Mr. Matz in mosaic disease tissue, is the real cause of the sugar-cane mosaic though the evidence so far points strongly in that direction. If this proves to be so this will be a case of a different kind where a comparatively large and conspicuous organism has been overlooked by a long series of pathologists simply because it is a strict parasite of an unusual kind and one that cannot be grown on ordinary culture media.

The general symptoms of this disease have been described so often that it seems unnecessary to repeat them here. Mr. Matz's paper shows that the lesions leading to the formation of cankers when near the surface of the stalk are also deep seated, and on their final collapse leave internal cavities which account for the light weight and lack of juice in the infected canes. These studies also show that the stuffed parenchyma cells that constitute the earlier stages of

these lesions can be detected in the very young tissue of the stalk and also in the young tissues of the leaf sheaths. In many varieties the more superficial ones may be detected with a hand lense in the very young and still soft internodes. This paper also shows that in the discolored areas of the leaves there is a lack not only of chlorophyll but of chloroplasts. These points should be added to the descriptive diagnosis of the disease. The fact should also be restated in this connection that in cases of recent infection the disease often appears in basal suckers within a few days of its appearance in the young terminal leaves although the matured leaves farther down on the stalk never develop the diseased symptoms. This shows that the infection has really invaded the entire stalk and the growing point of all the buds almost simultaneously.

Attention should be more forcibly called to other leaf spottings and discolorations that may be confused with the mosaic symptoms. In the course of these investigations the fact has developed that cane foliage is often attacked even in the unrolled bud spindle, by great numbers of several species of minute insects and mites which cause very considerable damage through the minute spotting of the leaves. Singularly enough, this damage has escaped the attention of the entomologists and some of the species are listed as cane insects for the first time in Mr. Smyth's paper on another page of this issue. Later these minute discolored specks often become invaded and enlarged by one or another facultative fungus parasite. We have a considerable literature on cane leaf spots as caused by fungi but there is little in print to show that in practically all cases the inciting cause of the spotting was the puncture of some minute insect. This however is the fact. In the later stages when invaded by fungi these leaf spots are sufficiently different from mosaic and there is no danger of confusing them. Many times, however, especially in old fields where the foliage is yellowish from root disease and bad cultivation, this minute insect spotting on the young unrolling leaves is sufficiently like the first indications of incipient mosaic infection to be very confusing. The mosaic disease, if present, however, very soon shows itself unmistakably and there is seldom any practical difficulty in distinguishing it. In examinations to determine the presence of mosaic disease attention should always be given to the youngest leaves, and especially to those not fully unrolled.

In all of his writings on the subject Stevenson has insisted on a three-year phase for this disease and he only describes the cankers

as occurring in the third or final stage. The present writer has been unable to confirm this view. The response of different varieties when attacked by the disease is so different that no general statement of this kind is possible. For instance, in the Santa Rita immunity experiment the Yellow Caledonia variety which was attacked by secondary infection soon after germination, developed serious stem cankers within six months and a number of the attacked stools were actually killed before the final inspection at the end of ten months. This was an extreme case but it is only one of many that show that the three-year phase idea is untenable. There is, however, usually a well-marked difference in the effect on the plant between primary infection from a diseased seed piece or diseased stubble and cases arising from secondary infection. In the former cases, except with the very resistant kinds like Java 36 (P. O. J.), which are scarcely affected by the presence of the disease, there is a pronounced dwarfing and all of the leaves on all of the shoots are equally affected. In secondary cases there is at first but little dwarfing and only one or a few of the stalks in the stool are involved. It is true that the course of an invasion by the disease has often resulted in what amounts to a three-year phase. In the first year a few scattered cases have appeared, perhaps by secondary infection but only too often from the criminally careless use of infected seed for replanting previously healthy ratoons. By the second year these cases have spread quite widely by secondary infection, but being secondary cases with a semiresistant variety like Rayada the damage has been comparatively slight. This would correspond to Stevenson's secondary phase. The following year with a considerable percentage of cases from diseased stubble the dwarfing effect would be much more obvious and losses of weight from cankered stalks would be much greater. With susceptible varieties like Otaheite, Cavengerie and Caledonia, this may end the productive life of the field, but as seen on page 9, fields of Rayada are known that though fully diseased for years at the fifth cutting gave as high as 20 tons of cane per acre in response to better cultivation and fertilization. That many diseased fields became valueless after the third year is freely admitted, but that the disease presents any approach to a three-year cycle must be strenuously denied.

11TH. CHEMICAL STUDIES OF DISEASED AS COMPARED WITH HEALTHY CANE.

The papers by director Colón and by Mr. López on other pages

of this issue are contributions to this subject. While the investigations have so far only been of a priliminary nature, they show no very striking chemical changes as a result of the presence of the disease. The earlier published statement that the diseased cane was very objectionable in the mill can refer only to those extreme cases where the cane became badly cracked. It seriously affects the quantity of the juice rather than its quality. Very much more than half of the cane ground this last year at all of the mills from Arecibo westward was diseased. The statistical report on sugar manufacture in Porto Rico issued by the Department of Finance gives for the 1919 crop not only the tons of sugar produced at each of the mills but the number of tons of cane ground. By averaging these figures for eight of the mills in the worst infected district we find that it required 9.88 tons of cane to produce a ton of sugar. At five representative mills from the eastern district where there was little or no disease the average was 9.32 tons of cane to the ton of sugar. So small a difference as this could easily be accounted for by differences in mill equipment and extraction or by weather conditions in different parts of the Island.

12TH. SOIL STUDIES; EFFECTS ON THE DISEASE OF DIFFERENT SOILS, SOIL STERILIZATION, SPECIAL FERTILIZERS, TOPICAL APPLICATIONS.

But little has been done under this heading. Field observations in all parts of the Island demonstrate that soil conditions have nothing to do with the spread of the disease. It is to be found on all types of soil on which cane is planted. Emphatically it is not a soil disease. On the other hand, good soils, abundant nitrogenous fertilizers and good cultivation while they will not ward off the disease will increase yields of cane that has become diseased. Many planters believe that liming the soil has some effect in preventing the disease. So far we have no exact facts in support of this theory.

An experiment was planted with the kind coöperation of Russel & Co. to test the effect of lime and sulfate of iron in combination with different fertilizers as follows:

Plot 1 at rate of 400 pounds tankage per acre.
Plot 2 at rate of 800 pounds tankage per acre.
Plot 3 at rate of 1,200 pounds tankage per acre.
Plot 4 check, no fertilizer.
Plot 5 at rate of 800 pounds tankage and 400 pounds sulfate of potash.
Plot 6 at rate of 800 pounds tankage and 400 pounds sulfate of amonia.
Plot 7 at rate of 800 pounds tankage and 800 pounds acid phosphate.

These plots were cross divided by three bands one of which received at rate of 4 tons of lime per acre, one 500 lbs. iron sulfate and the other no application. The intention was to have these plots planted with diseased Rayada seed cane. By some accident the seed selected was only about half diseased so that the cane came up very irregularly infected. The soil, too, developed unexpected irregularities in fertility before the fertilizers were applied. It is not expected, therefore, that this experiment will give conclusive results. At this writing it can only be said that the heavy applications of fertilizer have given a very heavy growth, but no very specific results can be noted from the different treatments. These plots will be cut and weighed when fully mature.[1]

13TH. RELATIONSHIP WITH OTHER SIMILAR DISEASES—A COMPARATIVE STUDY OF THE MOSAIC DISEASES.

Nothing has been done under this topic.

[1] A later inspection indicates a deleterious effect from the sulfate of iron and no appreciable effect from the lime.

THE MOTTLING DISEASE OF CANE AND THE SUGAR PRODUCTION OF PORTO RICO.

By C. A. Figueroa.

Since the year 1915 the cane growers of Porto Rico have been complaining that the sugar production of the Island has been diminishing with every succeeding crop. About the same time it was noticed that the fields were taking a yellowish color, the growth seemed to be handicapped, the stems were beginning to shrink and crack, and finally that the cane production per acre was getting to be less and less. To the disease presenting these symptoms was given the name of "matizado" or mottling disease.

A great many efforts have been made to control this disease, but so far they have proved to be of little value. To-day every cane-growing section of the Island is more or less infected.

About a year ago the students of the disease stated that the infection was "very general in the cane fields to the west of a line drawn from Bayamón on the north coast down to Guánica on the south coast." Only isolated cases were found to the east of this line. The progress of the disease since then is best shown by the following letter:

"My Dear Mr. Figueroa:

"In reply to yours of September 8, inquiring about the present extent of infection with *matizado* in the different cane growing districts, I would say as follows:

"From Bayamón to Barceloneta on the north coast infection is as yet only partial, but the disease is sufficiently abundant to constitute a commercial factor of importance. Your investigation will probably show some effect of the disease in lessening production in this district. As a rule the hill lands are more heavily infested than the *vegas*.

"From Arecibo to Central Coloso on the west coast the per cent of infection is considerably heavier than in this first district, but it is not total in all the fields, especially near the coast. Back in the hills the infection is very severe and very many hill fields have been abandoned.

"From Rincón around the west coast to San Germán the infection may be considered as total. Many of the fields are actually 100 per cent infested and very many over 90 per cent infested. It is doubtful if any field can be found that is not more than 50 per cent infested.

"From San Germán to Peñuelas the infection is very general and is now spreading more rapidly than in any other part of the Island. It is not yet, however, as complete as in the western district.

"At Central Mercedita near Ponce and in the fields about Juana Díaz there is considerable infection, but in the remainder of the south coast from Ponce to Patillas while the infection occurs locally at many places there is as yet too little to be a commercial factor.

"The same can be said of the entire east coast, though local outbreaks have occurred at Naguabo and Fajardo.

"Cayey is heavily infested.

"The district from Caguas to Juncos is partially infested but not sufficiently as yet to affect total yields very seriously.

"There is also a local outbreak at Trujillo Alto which extends to the neighborhood of Carolina.

"The above data, in connection with the other statistics you have gathered, should show quite conclusively the actual losses due to the *matizado.* I shall be very much interested to see your conclusions.

"Yours truly,

"(Signed) F. S. EARLE,
"*Expert in Cane Diseases.*"

The statistics that Professor Earle alludes to may be found in table form on page 40.

It will be noticed that the cane-growing zone of the Island has been divided according to Professor Earle's letter. A glance at the statistics will show that where the infection is most intense the sugar production has diminished most heavily.

The first section, which Professor Earle calls partially infested, (first zone) increased its acreage by over 4,400 *cuerdas* in 1918, nevertheless its sugar production was diminished by 2,850.31 tons. This figure represents 4½ per cent of the 1917 crop for the zone. The following year the acreage was diminished by over 450 *cuerdas* and then the loss of sugar goes up to about 18.3 per cent of the 1917 crop. It will also be seen that there is no proportion between the fluctuations in acreage as compared with the sugar output.

In the section from Arecibo to San Sebastián the infection is still greater than in the preceding one. Of this section Dr. Blouin of Louisiana says the following:

"In the district between San Pedro and Mayagüez, particularly in the Arecibo district, the damage has been very extensive. I visited three or four plantations in that district and the damage amounted to 40 per cent of the crop" —(*La. Planter and Sugar Manufacturer*, Oct. 18, 1919.)

The statistics show that this section has seen its sugar production reduced by about 40 per cent in two years.

The section from Rincón to Lajas offers a conclusive proof of the extent to which this disease interferes with production. In one year the sugar output is cut down to 67.6 per cent of the normal

and the next year it goes further down to nearly 60 per cent. This clearly shows the rapid progress of the disease in one year.

This has been partly due to the fact that seed has been very scarce in that section and lots of diseased seed have been used. These could be bought at very low prices. The writer in his report on a trip throughout this section was informed of this fact:

> "The fact that cane seed (cuttings) are being sold at a very low price in the San Germán valley induced me to look into the matter somewhat carefully. After some investigation I found healthy seed was exceedingly scarce in that section and this led many planters to use diseased seed which they can get at very low prices, thus helping to spread the disease in the most efficient manner. Lots of these diseased seed have been sold to the planters at Sabana Grande."

The section from Sabana Grande to Peñuelas has lost considerably. In this district, as in the first one here discussed, the infection has increased very rapidly and the losses in sugar have also increased accordingly.

In the south and east coasts of the Island the disease is only beginning to show. Losses here are greatly due to the lack of rainfall.

All students of this disease agree that its attacks are more severe in the hill plantings than in the lowlands of the coast. The Cayey and Adjuntas section prove this conclusively.

"The disease reduces the tonnage and therefore also reduces the production of sugar per acre." This statement was made by the director of the Insular Experiment Station in his Circular No. 14, and to back up his utterance he mentions the following experiences:

A Java experiment gave these results:

Healthy cane, 21.23 tons per acre, first crop.
Mottled cane, 18.20 tons per acre, first crop.

Results of a Hawaiian Experiment.

	Tonnage of 3 rows 80 feet long	Estimated tonnage per acre	No. of canes	Average weight per cane (lbs)	Tons of sugar per acre
Healthy cane	2 786	101 13	835	9 27	14.98
Mottled cane	1 5495	56 24	628	8 01	8.48

OTHER CONDITIONS AFFECTING THE SUGAR PRODUCTION.

This work will not be complete if it does not contain a brief discussion of all factors that may have had some influence on the sugar production. The writer does not pretend to assume that every pound

of sugar lost has been due to this disease. Though he firmly believes that the bulk of the loss is the result of the *matizado*, there are other causes to be taken into consideration.

RAINFALL.

The rainfall records available are not complete and for this reason they do not appear in this work. However, it is a well-known fact that the severe drouths that have occurred in different sections of the Island, particularly in the south coast and in the Arecibo-Aguadilla section, have contributed to lower production. Furthermore, the scanty amount of rainfall in certain sections like the eastern coast have come just at the wrong time.

But even so, it is not reasonable to blame the lack of rainfall for the whole trouble. The precipitation records that are complete show that there is no uniform relation between production and rainfall.

MANURES.

The following table[1] shows the importation of commercial manures by the district of Porto Rico during the last three years:

Year.	Tons	Value
1915–16	39,702	$1,735,391
1916–17	45,769	2,827,796
1917–18	40,811	2,929,726

This table shows that in the year 1917–18 the imports were cut down by 5,000 tons. It also shows that the cost of commercial manures has gone beyond the reach of the small cane grower.

But if the small planter has not used as much commercial manure as before the war, he has used more stable manure, guano, etc. Moreover, the manure-mixing plants of the Island have increased their capacity to a considerable extent, and consequently lots of manurial ingredients have been imported. It is very probable that all of these ingredients have not been imported under the head "Manures" or "Fertilizers" but as "Chemical Products." The enormous increase of importations under this heading appears to confirm this belief.

On the other hand, these 5,000 tons that were not imported last year are largely potash. All commercial manure users have missed this ingredient in their manures. This has led them to believe that lack of potash is to be blamed for the deficit in the sugar production.

However, manurial experiments on record in Porto Rico as far

[1] Customs House records.

back as 1910 have failed to show the economic advantage of the use of potash as a fertilizer in cane cultivation. Professor Earle says in connection with the use of potash:

"Potash should not be taken into consideration for its need is not so essential. Experiments with cane in Porto Rico show that the use of potash in these soils is of no such a great need. The demand for potash as a manure is one of the things 'Made in Germany.' Its use has been extended by means of the active propaganda of the 'German Kali Works.' For a good many years previous to the war this firm has been paying specialists in almost every agricultural country, whose business it was to work in favor of the potash." (Circ. No. 17, Ins. Exp. Sta., Recomendaciones sobre el Cultivo de la Caña en Puerto Rico.)

TILLAGE AND CULTIVATION.

All those interested in agriculture in Porto Rico agree in that our methods of tillage and cultivation are rapidly and constantly improving. A trip through the cane section will convince anybody of this fact. Soils are better prepared; more attention is paid to manurial and cultivation problems; seed selection is beginning to be popular; the sight of implements such as the tractor, the harrow, the disc plow and others is familiar now-a-days; and in short, the sugar men are beginning to realize that sugar cannot be made in the factories if proper attention is not paid to the agricultural end of the sugar business.

Comparing the acreage with production for the last three years we have—[1]

Year	Cane acreage *Cuerdas*	Total sugar output *Tons*	Tons of sugar per acre	Per cent decrease
1917	205,106	503,081.18	2.41	..
1918	256,431	453,975.55	1.77	9.7
1919	228,901	406,000.00	1.70	19.0

[1] From Bureau of Property Taxes and Report of the Treasurer

This means that, taking the crop of 1917 as a basis for calculation, Porto Rico has lost 146,186.81 tons of sugar in two years. This is about equal to 30 per cent of its normal production for one season. The figure is large enough to command some attention.

COMPARATIVE STATISTICS OF THE CANE ACREAGE AND AMOUNT OF SUGAR MANUFACTURED IN PORTO RICO IN THE CROPS FROM 1917 TO 1919.[1]

Zone	Municipality	Acreage of cane			Central	Sugar produced (T. 2 000 lbs.)			Decrease—T. 2,000			Per cent decrease	
		1916-17	1917-18	1918-19		Crop of 17	Crop of 18	Crop of 19	Crop of 18	Crop of 19	Decrease total	1918	1919
First Zone	Bayamón	2.116	2.840	2.869	Juanita	6.520 00	7.510 00	7.092 50					
	Toa Baja	3.302	4.284	4.023	Constancia	7.759 55	8.573.75	6.913 25					
	Toa Alta	975	1.406	1,355									
	Dorado	2.224	3 024	2.950									
	Vega Alta	1,069	2,346	2.196	Carmen	11,024.00	10 059.88	8.400 00					
	Vega Baja	4.464	4,008	3,957	San Vicente	12.044.00	10 925.00	10.379.00					
	Manatí	3 587	3.847	3.719	Monserrate	7.171 00	6,612 63	5.276 00					
	Barceloneta	4.038	4.419	4.648	Plazuela	16.510.00	14.487.88	11.749.00					
	Totales	21.775	26.174	25,717		61 019 55	58.169.24	49 809 75	2.850 00	11.209.80	14.060.11	4.6	18.3
Second Zone	Arecibo	11,872	14.687	13.811	Cambalache	23.1?9.00	15 197.63	11.021 00					
					Caños	6.353 68	5.129.38	4.375.25					
	Hatillo	1.973	3.718	3.616	Bayaney	745.00	946 00	1,367.50					
	Camuy	2,788	3.972	3.956	Soller	1.010 00	769 00	458 00					
					Alianza	4.808.00	2,343.51	1.243.00					
	Quebradillas	1,384	2.090	1.970									
	Isabela	1.018	1.567	1.527									
	Aguadilla	3.362	3,786	3.609	Coloso	13.501.50	12,690 06	11 021.00					
	Aguada	3.459	2.988	4.226									
	San Sebastián	835	1.380	1 313	Plata	1.795.60	1 854 00	1.462.00					
	Totales	26.691	34.189	34.028		51 312.78	38,929.58	30.947.75	12.413.00	20.395.03	32.808 23	24.1	39.7
Third Zone	Rincón	1.526	1,672	1.952	Córsica	11.044 00	7.581.00	7.392 88					
	Añasco	5,033	4,809	4.890									
	Mayagüez	4,968	4.166	4.284	Rochelaise	7,284.00	5,200.00	4.744.00					
					Ana María	7 993.38	5.135 00	3,969.89					
	Hormigueros	3,438	3.834	3,863	Eureka	6.084.00	3.980.00	3.527.?0					
	Cabo Rojo	6.878	7.563	7.626									
	San Germán	4.688	6 635	6.631									
	Lajas	8.073	6.353	6,339									
	Totales	34.604	35.033	35,587		32.405.38	21.896 00	19,633.77	10,609.38	12,771.61	23,380.99	32.4	39.4
Fourth Zone	Sabana Grande	1,466	1.881	2.054									
	Yauco	1.779	1,746	1.623									
	Guánica	3.193	4.281	4.317	Guánica	81.000.86	76.689 86	65.685.00					
	Guayanilla	1,890	1.857	1.904	Rufina	7.900.00	7.012.00	6.438.45					
					San Francisco	3.000.00	2.666.00	2.740.00					
	Peñuelas	1,609	1,848	1.991									
	Totales	9,987	11,618	11,889		91,900.86	86,367.86	74,868.45	5,533 00	17,087.41	22,670.41	6	17.4

Fifth Zone	Ponce	10.473	9.466	9.540	Mercedita	10.204.00	9.523.00	8,593.03					
					Constancia	2.206.00	4.508.73	1 590.00					
	Juana Díaz	8.113	8,117	8.195	Bocachica	14.925.00	16.231.00	13.180 00					
	Villalba		596	582									
	Santa Isabel	6.896	7.692	8,231	Cortada	10,780 00	11.173 00	8.932.00					
	Salinas	5,446	6 248	6.262	Aguirre	48.900.00	47.200.00	44.632 00					
	Guayama	8 580	7.447	7.237	Machete	10.557.00	10 237 00	9.845.00					
	Arroyo	2.622	2.775	2.766	Lafayette	8.685.00	7.826 00	13,093.75					
	Patillas	3.629	3,246	3.088	Providencia	5.200.00	4,[illegible]65 00						
	Totales	45,759	45.587	45,907		111.457.00	111.463.73	99.365 78		11.081.22	11,074.49		10.8
Sixth Zone	Cayey	982	1.745	1.757	Cayey	5.221.00	2.778.00	2,636.00	2,443.00	2,585.00	5.028.00	46.7	50.0
Seventh Zone	Maunabo	2,865	2.151	2.142	Columbia	7.223.50	6.052.00	5.189.00					
	Yabucoa	4.980	8,900	7,205	Mercedita	17,285.00	13.724 24	12.447.65					
	Humacao	5.679	7.440	8.286	Ejemplo	6,276 00	6.074 00	5,152 00					
					Pasto Viejo	11,156.87	10.777.00	9,681 13					
	Las Piedras	2,192	3.054	1.773									
	Ceiba	3.057	3.816	3.429									
	Naguabo	4,601	5.840	6.149	Triunfo	1.276.25	3.203.00	3.254.88					
	Fajardo	3,978	6.336	4,516	Fajardo	2[illegible],343.82	35.818 00	31 193.00					
	Totales	27,352	37.537	33.500		72.871.44	75.648.37	66.917.66					
Eighth Zone	Caguas	2,909	5.440	5,424	Santa Juana	11.114.00	7,187.00	7.031.00					
	Gurabo	2.491	3.393	2,869									
	Juncos	1.625	3.064	2 374	Juncos	14.925 00	16.231.00	13.180.50					
	San Lorenzo	1,142	1,229	1,229									
	Totales	8.167	13.126	11,896		26.039.00	23,418.00	20,211.50	2.621.00	5.827.50	8.448.50	10	22.2
Ninth Zone	Río Piedras	3,280	4.467	4.584	Vannina	10.543.00	12.135 25	11,733.25					
	Guaynabo	1,197	3.379	2.600									
	Carolina	2.925	4.445	3.716	Progreso	6.335.00	5.704 63	5.485.39					
	Trujillo Alto	1.013	1.549	1.531									
	Loíza	3,388	5,464	3,556	Canóvanas	14,706.13	15 413 50	15.184 25					
	Río Grande	3.193	3.898	3,895									
	Luquillo	2.895	4,151	4.209									
	Totales	17.891	27.353	24,091		31,584.13	33 253.38	32.402.89					
Tenth Zone	Jayuya	36	334	425	Santa Bárbara	957 00	798.65	585.28					
	Adjuntas	477	444	426	Pellejas	373.00	235.00	284 00					
	Totales	513	778	851		1.330.00	1,033.65	869.28	296.35	460.72	757.07	22.2	34.0

[1] From Report of the Treasurer of Porto Rico, statements of the Bureau of Property Taxes and figures from the Sugar Producers' Association.

THE ABSORPTION SPECTRUM OF THE CHLOROPHYLL IN YELLOW-STRIPED SUGAR-CANE.

By E. D. Colón.

Yellow stripe of sugar-cane is essentially characterized by the mosaic effect produced in the chlorophyll-bearing tissues, and more especially in the leaf blades, by the unequal intensity of the green color in those tissues. This unevenness in intensity is exhibited in areas whose size and pattern vary under different conditions. It ranges from deep green through shades of green, to almost white, and postulates a diminution in the amount of chlorophyll present in the lighter green areas and its almost total absence in the almost white areas.

In only two general ways could the disappearance of the pigment primarily be brought about: (1) By alterations involving the chlorophyll itself; (2) by alterations involving the chlorophyll-bearing bodies, the chloroplasts. The fact that red canes are also decolorized by the disease and, furthermore, that the young, uncolored internodes of certain varieties frequently exhibit faint purplish-red stripes when diseased, suggested an investigation of the possibility of the first alternative—*i. e.*, a general derangement of the chromogenic function in yelow-striped canes. Widbrink and Ledeboer[1] remark in this connection that in some leaves of young plants of the variety G. Z.–247 so much red coloring matter is formed under the influence of the disease that the blades take on a light chocolate tint against which the yellowish stripes and spots stand out. They further state that the cause of the striping in the stems is not due to the same cause in all varieties of sugar-cane and that in the varieties G. Z.–100, 247, 1639, 161, Yellow Batjam and many others the striping is due to the formation of anthocyanin.

Anthocyanin, carotin and xanthophyll, as well as many of the decomposition products of chlorophyll, are known to have characteristic absorption spectra. *Prima facie,* therefore, there appeared to be a strong possibility of any such wholesale modification of the normal chromogenic condition of the cane being detected by comparative spectroscopic examination of the extracted chlorophyll from both healthy and diseased leaves.

[1] Numbers in parenthesis refer to literature cited in bibliography appended.

Only newly attacked leaves were used. They were for a short time and separately extracted with ethyl alcohol after initial heating to boiling. Deep green, fluorescing solutions were obtained of each and their concentration equalized by comparative examination in the colorimeter. The spectroscopic examination of the ethyl chlorophyllide in solution was in all cases made through a ½ millimeter aperture of the jaws of the slit. Electric light was used for the illumination, the temperature of the air surrounding the globe next to the slit being from 30 to 35 degrees centigrade. The dilutions and thicknesses of solution examined will be seen in diagrams given below of the absorption spectrum repeatedly obtained.

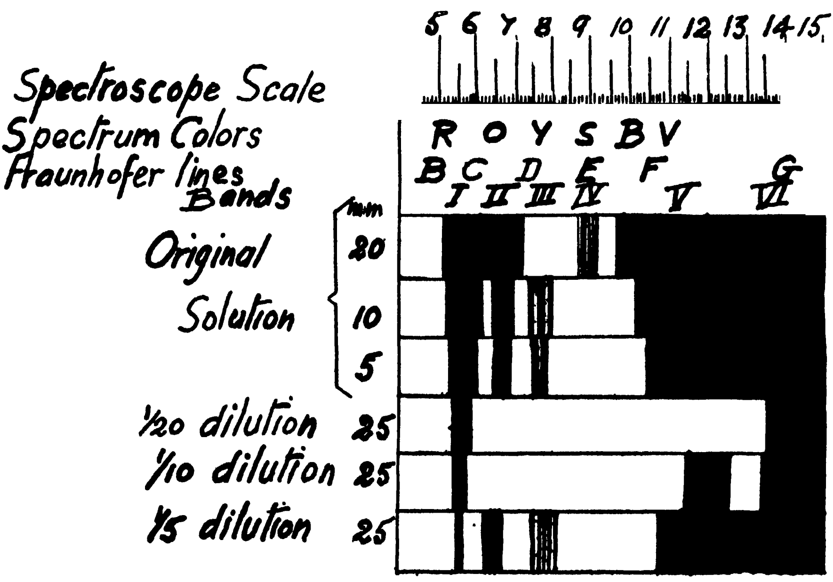

FIG. I.—Absorption spectrum repeatedly obtained by spectroscopic examination of young normal and yellow-striped sugar-cane leaves. The thickness of the layer employed is shown at the left in millimeters; the conventional letters of the Fraunhofer lines are at the top, so also the initials of the spectral colors, the spectroscope scale and the Roman numbers for the absorption bands. Aperture of the slit about one-half mm.; air temperature, 30°–35° C.

It will be apparent after glancing over the diagram that different dilutions and thicknesses of the chlorophyll solutions had to be examined before all the absortion bands could be made out. The absorption area in the more refrangible portion of the spectrum (including bands I, II, III) as well as that in the less refrangible portion (including bands V, VI) were present in all cases, their ex-

tension and distinctness depending on the conditions of examination. Band IV in the middle portion of the spectrum appeared to be the faintest of all, it having been distinctly brought out only in the most concentrated solution and when examined through the second greatest thickness employed (20 millimeters). The resolution of absorption area I, II, III into its three bands was brought about by examination of smaller thicknesses of solution (10 millimeters and 5 millimeters); that of absorption area V, VI by dilution combined with a larger thickness (25 millimeters).

It seems worth noting that band IV has been reported above as a faint band, the faintest of all, not as a dark one as represented in many discussions on the chlorophyll spectrum. In regard to this matter Dr. Edward Schunck states (2): "It should be mentioned that some of the absorption spectra figured in memoirs on chlorophyll really belong to the derivatives of the latter. Whenever in such figures band IV appears rather dark and is followed by another dark band nearer the blue end, we may conclude that the observer has worked with a specimen of chlorophyll that has undergone some change." The dark band nearer the blue end to which he refers has not been reported here as a distinct band, because although the absorption area V, VI may extend to that portion of the spectrum, we have not, nevertheless, been able to make it out as a separate band on further dilution as has been the case with bands V and VI. This has reduced to only six the total number of absorption bands reported here for chlorophyll in ethyl alcohol. Schunck (2), Allen (3), Palladin (4) and Pierce (5) report this number as six. Green (6), Goodale (7), Vines (8), Carracido (9) and Willstätter (10) report seven. Jost (11), reports a total of six, three before F and three beyond F, considering band IV before E as due not to chlorophyll but to a decomposition product of chlorophyll.

The absorption spectrum obtained for chlorophyll can thus be seen to have been fairly typical.

Now, the absorption spectra obtained for the alcoholic (ethyl) solution of chlorophyll from newly yellow-striped young leaves did not in our tests and under the same conditions exhibit any difference from the absorption spectra obtained for the alcoholic (ethyl) solution of healthy young leaves.

The four bands as figured in the diagram in the more refrangible portion of the spectrum are specially characteristic of chlorophyll. They constitute a certain test for this substance; so much so that Schunck (2), referring to the fact, says that chlorophyll "may ac-

cordingly be defined as the substance which in solution shows this particular absorption spectrum."

Should there have occurred any decomposition of the chlorophyll in the diseased leaves, the absorption spectra obtained from the examination of the alcoholic solution of their chlorophyll would not have, in the first place, been identical with the absorption spectra similarly obtained from healthy leaves. New bands or a modification of the old bands would in all probabilities have been noted, since other cane pigments and many decomposition products of chlorophyll are known to have characteristic absorption spectra. The fact that the decomposition of the chlorophyll would, in the case of the sugar-cane, have developed in an acid medium would have defined all the more the changes to be expected since the acid decomposition products of chlorophyll are fairly well known.

Although the tests above described were not as numerous nor performed with as many solvents as might have been desirable, they warrant the belief that the disappearance of the pigment in yellow stripe is not primarily due to a decomposition of the chlorophyll as such.

(To be continued.)

LITERATURE CITED.

1. Wilbrink, G., and Ledeboer, F. (1910.) Bijdrage tot de Kennis del Gele Strepenziekte. Mededeelingen van het Proefsta. voor de Java-Suikerind no. 39, pp. 443–496. 5 pls. (4 col.).
2. *Watt's Dictionary of Chemistry* (1912), Chlorophyll, p. 123.
3. *Allen's Commerical Organic Analysis*, p. 638.
4. Palladin, V. I. *Plant Physiology* (Livingston's Edition), Fig 4 (after Willstatter), p. 9.
5. Pierce, G. J. *A Text-Book of Plant Physiology* (1909), Fig. 1 (after Reinke), p. 54.
6. Green, J. R. *An Introduction to Vegetable Physiology*, p. 147 and Fig. 84 (after Krauss), p. 148.
7. Goodale, G. L. *Physiological Botany*, Fig. 150 (after Krauss), p. 293.
8. Vines, S. H. *Lectures on the Physiology of Plants* (1886), Fig. 1, plate after Pringsheim, p. 155.
9. Carracido, J. R. *Tratado de Química Biológica* (1917), p. 168.
10. Willstatter, R. *Handbuch Arbeitens Methodens Biochemichen* (Abderhalden).
11. Jost, L. *Lectures on Plant Physiology* (1907), p. 108.

HAS "YELLOW STRIPE" OR "MOTTLING" DISEASE ANY EFFECT ON THE SUGAR CONTENT OF CANE JUICE?

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Very early in the investigation of this disease the question arose as to its effect on the sugar content and purity of the juices of canes affected by it. From some quarters the claim was made that considerable inversion occurred in the juices of diseased canes and that consequently there was a great loss of sucrose and that much trouble ensued in the process of manufacture, especially at the crystallizing pans and at the centrifuges. An investigation of the point raised was therefore necessary. An attempt was made to find literature containing data that would bear on the question but with no practical results. Only two references to the subject could be found: One in The Hawaiian Planter's Record, Vol. X, No. 5, page 321, where two analyses are given, one of healthy and the other of diseased canes, in which both samples show practically the same sugar content, while the diseased canes show a higher purity; the other is a general statement in the report on the disease by G. Wilbrink and F. Ledeboer of the Java Experiment Station, to the effect that canes from diseased seeds produced, in their experiments, an average of 17 per cent less sugar than canes from healthy seeds. There is no indication, however, to show whether this loss was due to a reduction in the sugar content of the canes or to a decrease in tonnage. It was necessary, therefore, to plan for an investigation of the subject.

Some preliminary work had been done, but of very little value, so far as a definite conclusion on the subject was concerned. Some samples had been submitted to this division for analysis by Mr. J. A. Stevenson, then pathologist at this Station, in July and November of 1917. Mr. E. D. Colón, at that time working on the disease for the Division of Pathology had performed a number of analyses on healthy and diseased canes, and in a number of instances samples had been sent from plantations to have comparative tests made. The results of the samples submitted by Mr. Stevenson have been already published in THE JOURNAL OF THE DEPARTMENT OF AGRICULTURE OF PORTO RICO, Vol. IV, No. 1, for July 1919, pages 42 and 44, to which the reader is referred for details. Taken as a whole, these analyses did not lead to any practical conclusion, as no definite tendency was

manifest, and the variations would occur in all possible directions, regardless of the pathological condition of the plant.

A plan for a series of systematic analyses of healthy and diseased canes, that would eliminate as far as possible the variations due to the different factors that would bear on the results, was prepared by this division, in coöperation with the director, and the results obtained and the conclusions drawn from them are now presented in this paper.

The experiments were all performed at Central Bayaney, at Hatillo, whose board of directors extended their heartiest coöperation for the work, and did not spare any effort to help in every way possible to the success of the experiment. If everywhere the same spirit were shown, it would certainly be a pleasure to pursue lines of investigation which demanded coöperation of outsiders and many an agricultural problem would be more easily, cheaply, and wisely solved. In passing, I wish to extend my sincere thanks to the directors of Central Bayaney, and especially to the superintendent, Mr. Manuel Gorbea Pla, whose interest in the work did so much to overcome difficulties and make the work possible.

The analyses were performed on two different occasions: in May, 1919, toward the end of the grinding season by the assistant chemist, Mr. Rafael Vilá Mayo, and in December of the same year at the opening of the 1920 campaign by the writer.

PLAN OF THE EXPERIMENT.

The plan of the experiment was very simple. The basic idea was to make comparative analyses of healthy canes and canes in different stages of the disease growing under the same conditions, and showing as little individual differences between them as possible. The idea of taking separate samples of canes in different stages of the disease was suggested by previous work done on samples received from Central Cambalache. While working with these samples the writer noticed that marked differences were shown by the analyses of healthy canes and canes whose leaves were mottled but whose stalks were sound, on the one hand, and canes with cankered stalks on the other. Among the stalks which were cankered, some were badly cracked, and naturally, the idea suggested itself that the cracks in the stalks might be responsible for the differences observed. Accordingly, this point received due attention in the plan formulated. The following definite stages or manners of appearing of the disease were recognized: (1) canes whose leaves only were mot-

tled, but whose stalks were perfectly sound; (2) canes whose leaves were mottled and whose stalks were striped and slightly depressed near the joints; (3) canes whose leaves were mottled, and whose stalks were badly cankered but showed no cracks; and (4) canes whose leaves were mottled and whose stalks were both badly cankered and cracked.

In Mr. Vilá's work two series of analyses were made. In the first, series A, parallel analyses were made of healthy cane, cane showing the mottling in the leaves only and canes with stalks badly cankered, but not cracked. For these analyses Rayada cane was exclusively used. In the second, series B, the comparison was made between healthy cane, cane with mottled leaves only, and canes with stalks cankered and cracked. For this series Cavangerie cane was used, as not enough Rayada canes could be found with cracks in the stalks. The samples were taken in groups of three, each sample in the group consisting of five canes. All samples in a given group were taken from stools standing as close together as possible, using canes in different stages of the disease from the same stool whenever feasible. The individual canes were selected so as to have all the uniformity allowed by the circumstances as to age, development and maturity. Comparisons, therefore, should be made between the different samples in the same group, and not between samples belonging to different groups. Each group was marked with a number and the letter of the series

In the December work performed by the writer, four series of analyses were run: series C, D, E, and F. In these instances only two stages of the disease, instead of three, were compared at a time. Accordingly, groups of two samples each were taken and again five canes were allowed to each sample. All the precautions observed in the cutting of samples in the two previous series were carefully followed in taking these. As in this case only two samples were required for each group, it was possible to obtain them from the same stool, or from two adjacent stools more often, thus affording more opportunity for uniformity in the cane selected. Besides, only one class of canes, Rayada, was used in all the series, thus eliminating the possible element of variation due to varietal characteristics.

Series C was carried out with healthy canes, and canes which had the leaves only mottled. However, in groups 6–C, 8–C and 10–C, some stalks on the diseased samples were very slightly affected. The symptoms of the disease in these stalks were so slight that they were not thought to affect the results materially, and were preferred

to others which were perfectly sound, for their close proximity to the corresponding healthy stalks in the groups. This cane came from a *plantilla* (plant cane) planting which was one of the most vigorous in the place.

The purpose of the next two series, D and E, was to compare healthy canes with canes having mottled leaves and stalks visibly affected, but not cracked, and to see whether there was any difference in behavior between plant cane and ratoons. Accordingly, series D was run with plant canes, which had normal development, and were doing very well, and series E was run with samples from a field of fifth ratoons. In both cases the diseased canes showed striped, wrinkled internodes, depressed near the joints, and leaves heavily mottled. It is interesting to observe here that canes were found which, although having stalks in the condition just described, did not show any mottling in the leaves. Such canes were not included in the samples taken.

Series F. In this series canes with mottled leaves and sound stalks were compared with canes with stalks cankered and cracked Although a fifth ratoon, the plantation was producing larger canes and more cane than any other in the place. The stalks were large and fully developed, and the stools had twelve to eighteen or twenty canes each. The plants with sound stalks taken had their leaves very heavily mottled, and most of the plantation was in this condition. The affected stalks were profusely striped, with a number of cracks running along the lower half of the stalk. Some of the internodes were very much depressed, but others were only mottled and cracked. It was hard, however to find stalks in this condition as the percentage of canes affected in this way was very low.

The samples were brought to the laboratory and immediately analyzed. The juice was expressed in a handmill by passing the cane twice through the mill, which gave an extraction ranging from 51 to 60 per cent. The juices were strained through a copper wire strainer and the following determinations performed on them: degree brix, sucrose, acidity, reducing sugars.

METHODS OF ANALYSES.

Brix.—Was determined as usually with the common brix spindle, the temperature of the juice taken, and the correction for temperature introduced according to the table given by Spencer.

Sucrose.—Sucrose was determined by the single polarization method of Horne's, using dry lead subacetate for clarification. The

tables given by Spencer in the 1917 edition of his "Handbook for Cane-Sugar Manufacturers" were used for computing the sucrose from the polariscopic reading and the degree brix. The writer is aware of the fact that this method will not give the absolute per cent of sucrose in the juices, but it was thought to give sufficiently accurate results for comparative work.

Acidity.—It was intended to use logwood solution as indicator in the determination of acidity, but the reagent did not arrive in time for the spring work, so that Mr. Vilá had to use litmus instead. It was found, by previous tests, that more concordant results between duplicates could be obtained by using the paper rather than the extract. Ten cubic centimeters of the juice were taken, diluted with about 50 cc. of distilled water, and N/10 sodium hydroxide solution run in until neutralization, as shown by the permanence of color of two strips of litmus paper, one red and the other blue, dipped in the solution. However, by December we already had the desired logwood extract, and this indicator was used in the succeeding series of experiments. Again 10 cc. of the juice were diluted with 50 cc. of distilled water, so as to make more perceptible the change in color of the solution. This indicator was found to give very satisfactory results. As shown in the tables, the acidity has been expressed as cubic centimeters of N/10 alkali solution required to neutralize 100 cc. of juice.

Reducing sugars.—Under the limitations and lack of facilities in which this work was carried out the gravimetric method, which would have been preferred by the writer, could not be used. In looking for a volumetric method, accuracy and speed were the factors considered. The method had to be rapid enough to allow of a number of determinations being made by a single manipulator with very scant equipment, in a short time, as it was not desired to preserve juices for any length of time for this work. These determinations were to be made in fresh juice, as soon as possible after being expressed from the canes. Consider that only one alcohol lamp was available, and that consequently not more than one sample could be heated at a time. Duplicates were made of all determinations, and in some doubtful cases three and four determinations were made on a single sample.

Having all these conditions in mind the method of Schoorl de Haas was chosen. Accordingly, the following solutions and reagents were prepared:

1. *Copper sulphate solution.*—69.28 grams of chemically pure

copper sulphate crystals were dissolved in 1 liter of distilled water. This solution was standardized against N/10 sodium thiosulphate as explained below. The reducing sugar equivalent of this solution was then determined by carrying out a test exactly as described for the juices, except that a standard solution of reducing sugar prepared by inverting c. p. sucrose was used.

2. *Alkaline tartrate solution.*—Prepared by dissolving 346 grams of Rochelle salts and 100 grams of sodium of hydroxide per liter.

3. *Tenth normal sodium thiosulphate solution.*—A tenth normal solution of sodium thiosulphate was prepared, and titrated against a mixture of 5 cc. of the copper sulphate solution and 5 cc. of the alkaline tartrate after boiling for exactly two minutes and the addition of 20 cc. of 20 per cent potassium iodide sol., and 10 cc. of dilute sulphuric acid prepared as directed below. From this the equivalence of both solutions was found. All details given for the actual carrying out of the method with juices should be observed in this titration.

4. *Potassium iodide solution.*—A 20 per cent solution of potassium iodide solution was prepared.

5. *Dilute sulphuric acid.*—The solution was made by mixing equal volumes of chemically pure sulphuric acid sp. gr. 1.84 and distilled water.

Procedure.—Ten cubic centimeters of juice were diluted to a volume of 100 cc.

To ten cubic centimeters of the juice solution, 5 cc. of the copper sulphate solution and 5 cc. of the alkaline tartrate solution were added in an Erlenmeyer flask of about 300 cc. capacity. The flask was then quickly brought to boiling, and the boiling continued for exactly two minutes, at the end of which time the flask was suddenly brought under the tap and rapidly cooled to about 60° C. Twenty cubic centimeters of the 20 per cent potassium iodide solution were then added, and then 10 cc. of dilute sulphuric acid. The copper sulphate not reduced by the juice was then immediately titrated with N/10 thiosulphate solution using starch as indicator, to a very pale or almost white color. From the number of cubic centimeters of thiosulphate required for each cubic centimeter of copper sulphate solution as already determined, the volume of copper sulphate solution not reduced by the juice was calculated. This amount, subtracted from the 5 cc. of copper sulphate solution used, leaves the number of cubic centimeters of copper sulphate solution reduced by the juice. From the reducing sugar equivalent of the copper sulphate solution

the amount of reducing sugar in the 10 cc. of juice solution taken was found, and the percentage then calculated.

RESULTS AND CONCLUSIONS.

The results are presented below in tabular form and in graphs plotted from the data given in each table, so that for each table there is a corresponding graph.

In plotting the curves only the data for sucrose, acidity and reducing sugars have been made use of, as these are the real dominant factors, and the inclusion of the degree brix and the purity would contribute nothing in this instance toward reaching a conclusion, while introducing more or less confusion in the diagrams.

As the purpose is to compare the condition of the samples in each group with one another rather than to compare results between different groups, the numbers of the groups were taken for abscisae and the percentage of sucrose and invert sugar, and the acidity expressed in cubic centimeters of N/10 caustic soda per 100 cc. of juice, for ordinates. It is clear, then, that there is no relation to be expected or found between ordinates and abscisae, and that the diagrams only purpose to show the comparison between the samples in each group irrespective of the other groups, by means of the relative positions of the corresponding points in each group. In other words, the results obtained for all samples in a given group appear represented by points in the same vertical line, and that line is marked at its foot on the horizontal designated "Base line" with the number corresponding to the given group. The points were placed by counting up from the base line the number of centimeters corresponding to the percentage which they intended to represent according to the scale given in each diagram for each group of lines. The points by themselves, then, would have been sufficient, but they have been connected by lines as a help to the eye and to the imagination in establishing comparisons between the different positions.

Special attention should be called to the graphs plotted from Table II. Here some points appear which have not been connected by lines. The explanation is as follows: In groups 4 and 6 the samples corresponding to the mottled canes, and in group 5 the samples corresponding to the healthy cane, were lost, so that no figures appear for these in the table. No points appear in the graph for these corresponding positions. This left isolated the points corresponding to the samples of mottled cane in positions 5 and 7, and they are shown by points surrounded by circles of red broken lines

It will be noticed that, for the sake of contrast, the points on black lines are indicated by red circles, and the points in red lines by black circles. Where two concentric rings are seen as in the acidity curves at positions 1 and 2, it means that the points belonging to two different samples coincided. In these instances the acidity of the healthy and the mottled canes was exactly the same.

The horizontal straight lines mark the levels for the averages in each set of samples of canes affected to the same extent by the disease.

TABLE I—SERIES A.

COMPARATIVE ANALYSES OF HEALTHY CANES, CANES WITH THE LEAVES MOTTLETD AND SOUND STALKS, AND CANES WITH LEAVES MOTLED AND STALKS AFFECTED, BUT NOT CRACKED.

The different stages are distinguished in the table below by the terms "healthy," "mottled," and "cankered," respectively.

RAYADA—MAY 3 TO 10, 1919.

Group No.	Brix			Sucrose			Purity			Acidity. Cubic cent. N/10 NaOH per 100 cc Juice		
	Healthy	Mottled	Cankered	Healthy	Mottled	Cankered	Healthy	Mottled	Cankered	Healthy	Mottled	Cankered
1—A	19.00	18.80	18.60	15.70	16.00	15.30	81.60	85.10	82.26	5.80cc.	6 60cc.	7 20cc.
2—A	18.80	18.70	18.30	17.00	16 83	15.90	90.42	90.00	86 89	4.40	4 60cc.	6.00cc.
3—A	18.20	18.60	18.40	16 5	16.78	16.70	90 66	90.10	90.79	5.60cc.	5 20cc.	5.20cc.
4—A	17.20	17 60	17 00	15 51	15.90	15 70	90.17	90 84	92 94	1.80cc	2 60cc	4.80cc.
5—A	17 40	17.70	17.10	15 50	16 30	15 40	89.08	92.09	90.05	1 10cc.	1 80cc	4 60cc.
6—A	19.80	18 60	18 50	17.03	16.77	15 70	88 20	90 20	84.90	3 50cc	2 40cc.	5.80cc.
7—A	18 40	18.60	16.90	17 00	16.76	14 55	92.40	90.10	86.10	8.30cc.	2.70cc.	4.50cc.
Averages	18.328	18.371	17.828	16.32	16.477	15.607	89.044	89 690	87.542	3.685cc.	3.700cc.	5 442cc.

On closely examining Table I, we find that by comparing the analyses of the different samples in the same group we do not discover any great discrepancies as regards the degree brix, the sucrose content and the purity of the juice. Out of seven groups analyzed in only four instances is there a decrease in the sucrose content of the cankered canes as compared with healthy canes, and in only three instances is the purity lower in the cankered than in the healthy canes. In only one instance is there a considerable difference in favor of the healthy canes, in group 7-A, in which the difference in sucrose reaches 2.45 per cent, and the purity is 6.3 points lower in the cankered cane. But this seems to be a case in which individual variations affected heavily the analysis of the sample, as it is the

only instance in which such discrepancies are manifested. In two other cases only is the sucrose content of the cankered cane lower than that of the healthy cane by as much as 1 per cent. These are in groups 2 and 6. Turning now to the averages, we find both sucrose and purity lower in the cankered canes, but if the exceptional instance of group No. 7 is left out, these differences become too small to deserve consideration. Thus, averaging only the degree brix and the sucrose of the first six groups of cankered canes, and finding from the averages obtained the resulting purity, we get 17.983 for the brix, 15.783 for sucrose and 87.771 for purity. These will produce the differences of only 0.563 in sucrose and 1.273 in purity when compared with the averages of the samples of healthy canes.

An inspection of the sucrose curves constructed with these figures show these points very clearly. It will be noticed that only the extreme point to the right of the red curve falls at a considerable distance below the corresponding point in the whole black line, and that only in two other cases at positions 2 and 6 show the corresponding points a noticeable difference in levels. In other cases the points in the red line are either a very short distance below, or slightly above those in the curve for healthy cane. It should be remembered that a distance of 1 mm. in the diagram shows a difference of only 0.1 per cent sucrose. The lines of averages, however. show a tendency toward a decrease on the part of the diseased cane, as mentioned in the discussion ~~of the~~ table. The conclusion seems warranted that the cankering of the stalk affects very little the sucrose content of the juice of diseased canes; or at least, that the extent to which it is affected would not be noticeable under factory conditions.

As for the cane having the leaves only mottled, a mere glance at the figures is enough to show that there is no difference between their juice and that of healthy canes. If anything, they seem to show up slightly better than the healty ones.

This is very well shown by the graph. As seen, the points in the curve for mottled cane appear in four instances above those in the same vertical line for healthy cane, while in the other three cases the points for the mottled are only very slightly below those for healthy cane in the same group. This shows no more variation than could be expected if duplicate samples of healthy canes only had been analysed. Notice that the line of averages for the mottled cane reaches a higher level than that for healthy cane, but that the dif-

ference in levels is very little. It might as well have fallen below by about the same distance, for all we know.

With regard to acidity, the averages show that there is no difference between healthy and mottled cane, but cankered canes show a higher content, the excess being on the average equal to 1.757 cc. of N/10 caustic soda per 100 cc. of juice equivalent to 0.007028 gms. caustic soda in 100 cc. of juice. The curves for acidity as plotted from this table hardly need any comment. The coincidence of the two lines of averages corresponding to healthy and mottled cane as well as the relative positions of the corresponding points in the curves for these two classes of cane speak for themselves. The levels attained by the points in the curve for cankered cane as well as the line representing the average content show the greater acidity contained by these canes.

TABLE II—SERIES B.

COMPARATIVE ANALYSES OF HEALTHY CANES, CANES WITH LEAVES MOTTLED AND SOUND STALKS, AND CANES WITH CANKERED, CRACKED STALKS.

The different stages are distinguished in the table below by the terms "healthy," "mottled," and "cankered," respectively.

CAVANGERIE—MAY 3 TO 10, 1919.

Group No.	Brix			Sucrose			Purity			Acidity. Cubic cent N/10 NaOH per 100 cc. Juice		
	Healthy	Mottled	Cankered	Healthy	Mottled	Cank red	Healthy	Mottled	Cankered	Healthy	Mottled	Cankered
1-B	18.(0	17.90	18 00	16 16	16 00	15.25	89.80	89 88	81 72	6 80cc.	6 80cc.	10 C0cc.
2-B.	18 00	17 10	14.90	16 28	16.10	12 15	90 41	92 52	81 54	2 60cc.	2 60cc	6 00cc.
3-B.	18 20	18.20	15 50	16.40	18.78	11 90	90 40	92 17	76.77	1 80cc.	3 70cc.	7 20cc.
4—B....	18 10	...	15 10	16 36		11 75	88.96	.	76 30	5.60cc	... ...	8 10cc.
5—B...........	...	17.10	16 10	...	15.70	12.15	.....	91.81	75.46	... ...	5 60cc	7 20cc.
6 B..	18 80	....	16 60	16 74	.	13 85	80.00	....	83 43	1.70cc	... ...	6 00cc.
7—B...........	17 70	18.40	17 00	15.92	15.48	14.44	'0.00	84.13	85 00	2.80cc	5 80cc.	5 70cc.
Averages ...	18.183	17.80	16.214	16.31	16.012	13.07	89.609	89.055	80.609	4 55cc.	4 90cc.	7 257cc.

Looking now at Table No. II, we find a very different state of affairs as regards the composition of the juices of cankered canes as compared with the juices of healthy canes. Here the difference is apparent at first sight. The degree brix, sucrose content, and purity, appear consistently lower in the cankered canes. In groups 2–B and 4–B the difference in sucrose reaches over 4 points, being 4.61 in the latter, while the average of all the differences is as high as 3.066 points. Taking the difference between the two sucrose averages

(average for healthy cane, and average for cankered cane), we obtain a difference of 3.24 points in favor of the healthy cane. In purity we find differences as high as 12 and 13 points in groups 3–B and 4–B, the lowest difference being of 5 points, in group 7–B. Comparing the averages, we find a difference of 9.090 between the purity and healthy cane and that of cankered cane. The figures for the mottled cane again fail to show any appreciable differences with the healthy cane as regards sucrose and purity.

A slight gain in acidity is evidenced by the average of mottled canes compared with that of healthy canes, but as no consistency in the differences shown by the samples in the individual groups is apparent, no conclusion should be based on this fact. There is no question as to the higher acid content of the cankered canes. It should be noticed that the acidity in these canes is higher than that shown by the cankered canes in the previous series. Altough for reasons that could not be controlled at the moment a determination of reducing sugars could not be made in every case, yet those that were made consistently showed that considerable inversion occurred in the juices of canes whose stalks presented fissures as a result of the disease.

Notice now the curves plotted from the data in this table, (Table No. II). The sucrose and acidity curves for healthy and mottled cane follow pretty close one another and the differences between their lines of averages are not of much consequence. The fact that relative positions of the lines of average for sucrose (as *regards healthy and "mottled" cane*) are in this case the inverse of what they are in the previous graph, further justify our conclusion that the mere mottling of the leaves do not seem to affect the sucrose content of cane to any appreciable extent.

The curves for the cankered cane with cracked stalks, however, strikingly show the lower sugar content and higher acidity in these canes. It is well to notice that with the exception of the points in positions 1 and 2, the points in the acidity curve attain higher levels and those in the sucrose curve appear at lower levels simultaneously, thus showing a corresponding decrease in sucrose whenever an increase in acidity is present. This correspondence will be further evidenced in the diagrams that follow. It is plain that this has been a clear case of fermentation due to the cracks in the rind of the cane.

The conclusion is irresistible that the cracking of the stalks causes inversion in the juices, with the consequent loss of sucrose. The higher acid content in these canes point to fermentation as the cause of this inversion.

Reasoning from the results obtained in these series of analyses, the conclusion should be reached that the disease in itself does not affect to any appreciable extent the sucrose content in the juice, and that it is only when the stalks are cracked and fermentation ensues that a considerable decrease in the sucrose content results, as it would result in any other case in which a cane had sustained mechanical injury enough to cause the exposure of its inner tissues. At an advanced stage, the disease, however, seems to induce of itself an acid condition of the juice, but not to any considerable extent.

We shall see whether this thesis is sustained by the results obtained in the experiments that follow.

TABLE III—SERIES C.

COMPARATIVE ANALYSES OF HEALTHY AND MOTTLED CANES.

The diseased canes had only the leaves mottled.

PLANT CANE—DECEMBER 9, 1919.

Group No.	Brix		Sucrose		Purity		Cu Cent. of n/10 Na OH per 100 cc. Juice		Reducing Sugars	
	Healthy	Diseased	Healthy	Diseased	Healthy	Diseased	Healthy	Diseased	Healthy	Diseased
1—C.	.	16 73	..	15 13	....	90.43	....	3.00	....	0.674%
2—C	17.47	15 31	15 71	12.13	89 92	81.18	2 50	2 50	0 474	1.444%
3—C	17 39	17.20	16 65	15 71	95 74	91.36	2.50	3.25	0.428	1.180%
4-C..	16 87	17 29	15 67	15 90	92 88	91 06	4.00	5.25	0.487	0.284%
5—C	17 83	16 73	16.80	15 52	91.22	92.76	5.50	5.00	0.323	0.291%
6 C......	14 59	15 23	11 00	11 94	75 39	78.39	3.00	8.50	1.549	1.251%
7 C...........	16 66	15 99	11 12	13 85	81 75	86 61	3.25	4 25	1 067	0.582%
8—C	17.16	16 26	15 62	14 04	91 02	86.34	1 00	3 75	0.352	0.261%
9—C.....	15.73	15 76	12 52	12 57	79 59	79.76	1.75	6.12	1.131	0.942%
0-C..	17.56	17 56	15.82	15 80	90 09	89.97	2 00	4 00	....	0 359%
Averages ...	16.806	16.406	14.879	14.280	88.584	87.09	3.166	4.562	0.726	0.722%

An inspection of Table III will reveal the fact that no constant difference is introduced in the sugar content of the juices by canes attacked with the disease in which *only the leaves* have become mottled. The differences between the samples in each individual group point sometimes one way and then another, while the averages come as close to each other as could be expected under the circumstances. Slight differences in averages, cannot be taken, of course, as the guiding-principle in a work of this nature. It is only a reasonably consistent series of differences all pointing the same way what should be taken as an indication of a cause uniformly acting to produce a given effect.

A study of the curves plotted from the data presented in this table will reveal very interesting points. Although judging from the lines of averages for reducing sugars there is no difference as between the healthy and diseased canes, and while only a small difference in favor of the healthy cane is shown by the sucrose curves, yet there is shown a higher acid content by the diseased canes. This increase in acidity is constant throughout all the series in which this factor has been included. It is further to be noticed here, as well as further on, that this difference, though constant, is very small in all cases except in very acute stages of the disease, reaching its maximum development only when the stalks crack. But this point may be better discussed after all the other tables and curves have been examined. For the present it is enough to notice that the extra acidity induced is not enough to cause inversion, as shown by the coindicence of the lines of averages for reducing sugar.

Table IV and V show comparisons of healthy canes with canes which had mottled leaves and stalks depressed near the joints, but which showed no cracks or fissures in the stalks. In the first, plant cane was used, while in the second, ratoons were chosen. Both point to the same conclusion.

TABLE IV—SERIES D.

COMPARATIVE ANALYSES OF MOTTLED AND HEALTHY CANES.

The diseased canes in this series had the leaves mottled and the stalks affected but not cracked.

PLANT CANE—DECEMBER 17 TO 18, 1919.

Group No.	Brix		Sucrose		Purity	
	Healthy	Mottled	Healthy	Mottled	Healthy	Mottled
1-D	(X)	15.16	....	12.56	....	82.84
2-D	(X)	15.49	....	12.52	....	80.82
3-D	16.03	16 08	12.96	13.21	80 84	82.41
4-D	17.19	15.89	14.58	12.96	84 81	81.56
5-D	14.78	14 86	10.85	12.42	73.66	83.58
6-D	15.86	16.03	12 73	12.99	80.04	81.08
7-D	16.89	15.86	13.46	13.26	82.12	83.60
8-D	16.49	16.39	13.56	12.33	82 23	75 22
9-D	15.93	15.43	12.49	12.28	78.88	79.56
10-D	16.83	15.98	12.99	12.99	79.54	81.54
11-D	16.19	16.56	13.11	13.81	80 79	83 57
12-D	17.26	16.59	14.01	14 10	81.17	84.99
13-D	14.96	14.96	11.51	12.10	76.93	80.88
14-D	15.59	14.96	12.71	12.10	81.52	80.88
15-D	16.79	17.19	14.84	14.06	85.00	87.02
Averages	16.184	15.622	13.027	12.914	80.742	81.620

In Table IV, out of 13 instances in which a comparison could be established in only 5 cases did the diseased cane show a lower sucrose

content, and in only three cases was the purity of the diseased cane juices less than that of the healthy ones. The highest difference in sucrose in favor of the healthy canes was 1.62 points in group 4–D, in three other cases, groups 7–D, 8–D and 9–D, the difference was only of 0.20 to 0.23 points, and in group 14–D, of 0.61. In the three cases of lower purities, the differences were 7.01 points in group 8–D, 3.35 points in group 4–D, and 0.64 points in group 14–D. In 10 instances out of 15, and in 12 out of 15, the sucrose content and purity were respectively higher in the diseased canes. These considerations more than counterbalance the slight differences shown in the averages in favor of the healthy cane.

In Table V, the averages for the diseased and healthy canes show a wonderful agreement considering the circumstances. These figures hardly need any discussion; they speak clearly for themselves. There are no constant differences to speak of among the samples in each group or between the total averages obtained. Only in the case of the acidity seems there to be a tendency to show a slight constant difference pointing to an increase in the diseased canes. The differences, however, are very small.

TABLE V—SERIES E.

COMPARATIVE ANALYSES OF MOTTLED AND HEALTHY CANES.

The diseased canes had their leaves mottled and the stalks affected but not cracked.

RATOONS—DECEMBER 20 TO 22, 1919.

Group No.	Brix		Sucrose		Purity		Acidity		Reducing Sugars	
	Healthy	Mottled	Healthy	Mottled	Healthy	Mottled	Healthy	Mottled	Healthy	Mottled
1–E	17.89	17.49	15.85	15.15	88.59	86.62	2.25cc	2.50cc	0.766%	0.856%
3–E	17.69	14.36	15.90	13.75	89.88	95.75	1.75cc	2.25cc	0.517%	1.087%
5–E	17.19	15.29	15.42	12.52	89.70	81.88	2.50cc	4.10cc	0.482%	0.920%
6–E	17.26	17.29	14.90	15.32	86.32	88.60	1.75cc	2.25cc	0.872%	0.884%
7–E	15.06	16.56	12.40	13.81	82.33	83.39	3.00cc	2.75cc	0.805%	0.904%
8–E	16.79	16.84	14.98	14.22	89.22	84.44	2.50cc	4.25cc	0.687%	0.814%
9–E	13.56	17.39	10.50	15.36	77.43	88.32	2.75cc	2.50cc	1.625%	0.679%
10–E	16.96	17.26	[illegible].15	14.79	89.32	85.68	2.50cc	2.75cc	0.814%	0.880%
11–E	17.06	15.56	[illegible]2	12.79	83.93	82.19	2.50cc	3.75cc	1.248%	1.079%
12–E	16.29	16.53	[illegible].02	14.23	86.06	86.08	1.75cc	2.50cc	0.901%	0.880%
Averages	16.575	16.457	[illegible].344	14.194	86.539	86.249	2.325cc	2.960cc	0.8712	0.8383

These facts are more forcefully presented by the graphs corresponding to these tables. The sucrose curves plotted from Table IV

continually overlap, thus showing normal differences, as should be expected in different samples even of canes carefully selected to eliminate individual variations. There is not shown, or even suggested, a preponderance on the part of any of the sets of samples upon the other. The slight differences between the levels of the lines of averages in favor of the healthy cane cannot serve as the basis of a conclusion, in view of the lack of uniformity in the variations in the individual groups. The same comments apply with equal force to the sucrose and reducing sugar curves in Diagram V. Discussing further the curves plotted from Table V, we find again the increased acidity present in the diseased canes, in spite of the fact that the average for reducing sugars in these canes is slightly lower. Again this offers the suggestion that the slight increase in acidity has not been enough to cause inversion.

It should be noticed here as well as in the curves constructed from Table III that in fully 50 per cent of the cases compared the curves show an equal or lower glucose ratio for the diseased canes, a proof that the increase in acidity has not been enough to produce inversion. This may be seen by comparing the positions of corresponding points for sucrose and reducing sugars in each group of samples. Thus, in Graph III, and referring to groups number 4, 6, 7 8 and 9 the distances from the base line to the points in the reducing sugar curve for diseased canes show a lower ratio to the distance from the base line to the points in the sucrose curve of these canes than the ratio shown by the distances indicated by the corresponding points in the curves for healthy cane. Remember that in only eight cases is this comparison possible as there were no reducing sugar determinations made in healthy cane groups 1 and 10. Refering now to Graph V and groups number 6, 7, 9 and 10, the ratios between the distances from the base line to the points in the red curve for reducing sugars and the distances from the base line to the corresponding points in the red line for sucrose is lower than the ratios shown by corresponding pairs of points on the black curves for reducing sugars and sucrose, while in groups number 11 and 12, these ratios are practically the same.

The two tables show rather conclusively that whether you take plant canes or ratoons the juice of the canes remain practically unaffected by the disease, (except for a slight increase in acidity noticeable in the juice of diseased canes), even when the stalks have become affected, provided that they preserve their rind whole, and no cracks have been formed.

TABLE VI—SERIES F.

COMPARATIVE ANALYSES OF CANES IN AN ADVANCED STAGE OF THE MOTTLING DISEASE AND OF CANES SHOWING ONLY THE FIRST SYMPTOMS.

In the former the stalks were badly cankered, showing cracks at intervals, while in the latter only the leaves were mottled, the stalks being in good condition. In the following the terms "cankered" and "mottled only" will be used to distinguish between them. No glucose determinations were made for lack of reagents.

RATOONS

Group No	Brix		Sucrose		Purity	
	Cankered	Mottled only	Cankered	Mottled only	Cankered	Mottled only
1-F	13 79	17 39	9 71	15 76	70 6	90 62
2-F	18 71	16 89	17 34	15 07	92 67	89 21
3-F	11 86	17 56	11 78	16 05	79 27	91 40
4-F	17 13	17 23	15 42	14 97	90 00	86 88
5-F	13 79	15 89	10 50	13 50	76 11	83 70
Averages	15 656	16 992	12 956	15 0 0	82 766	88 452

Table VI affords an opportunity of comparing diseased canes with fissures in their stalks, with mottled canes having sound stalks. The differences again stand out clearly showing the effect of the cracks. It should be observed that aside of the cracks and the stripes shown by the stalks, these canes were well developed, and that in some of the samples the cracks were more numerous than in others. This accounts for the good showing made by two of the samples. The averages, besides, show appreciable differences. It is to be regretted that more samples of this type could not be secured, but the time available for the work was short, and searching for the few scattered samples of this sort that could be obtained in the place proved to be a time-consuming operation.

The curves plotted to represent the variations shown by this table hardly need any more comment than what has been said in connection with the table itself. The difference between the lines of averages is enough to point out the direction in which the changes occur. In the samples where the number of cracks was noticeable the difference in sucrose is striking, as shown by points in positions 1, 3 and 5. The two points showing a high sucrose content serve as further proof of the conclusion reached, as they were the samples with only a small number of cracks.

The results, further more, corroborate those obtained by Mr. Vilá, and shown in Table II.

SUMMARY.

1. Parallel analyses of healthy cane, cane with mottled leaves, and canes with leaves mottled and stalks affected by the disease but not cracked, conducted during the spring of 1919, failed to show any difference in the sugar content of the canes compared. A slight gain in acidity was observed on the part of the cankered canes. The canes used were of the Rayada variety.

2. A second series of parallel analyses using Cavengerie cane and substituting canes with the stalks cracked for the cankered canes with the stalks whole revealed higher acidity, lower sucrose content, and in the cases where tests were made, a higher content of reducing sugars in the cankered, cracked canes. No differences that deserve mention were noticed on comparing the canes with mottled leaves with the healthy ones, except for a slight tendency toward a higher acid content shown by the former.

3. Comparisons between healthy canes and canes with leaves mottled but unaffected stalks conducted in December, 1919, did not show any constant differences in sucrose, or reducing sugars, but again the increased acid content of the mottled canes, though small was noticeable.

4. Comparative analyses of diseased canes having their stalks affected, but not cracked, with healthy canes, using both plant cane and ratoons performed in December, failed again to show any appreciable differences in their juice composition as regards sugar content; the acidity, however, showed a slight increase in the diseased cane.

5. A series of experiments conducted to compare diseased, cankered canes having the stalks cracked, with diseased canes having sound stalks showed lower sucrose content and lower purity in the former.

CONCLUSION.

The general conclusion is forced by the facts as revealed by these series of analyses that the mottling or yellow-stripe disease does not affect materially the sugar content of the juice of canes attacked with the disease, except in an indirect way, when the stalks become cracked as a result of the drying up of the stalk. In this case the

exposure of the inner tissues brings about fermentation, as in the case of any other mechanical injury received by the stalk bad enough to cause cracking of the rind, with the subsequent increase of acidity, inversion, and loss of sucrose. There is, however, a tendency on the part of diseased canes to show an increase in the acid content of the juices, but this increase is not serious enough to cause inversion, except in very acute stages of the disease, and after the stalks have become cracked as a result of being badly cankered.

INFECTION AND NATURE OF THE YELLOW STRIPE DISEASE OF CANE (MOSAIC, MOTTLING, ETC.)

By J. Matz.

INTRODUCTION.

In December, 1918, the writer began studies of this disease in Porto Rico. The following is a summary of experiments and histological studies made during a period of twelve months. Owing to the conflicting views among investigators regarding the nature of this disease there could not be obtained much guidance as to any one definite line of investigation to follow out, so that even previous experiments carried out by others had to be repeated in order to gain a clear path for any line of investigation.

In reviewing the literature on this disease it was found that although the disease has been recorded to have appeared in cane fields which were previously known to be free from any visible signs of it, yet there is hardly any records of exact observations of its transmissibility to known healthy plants. There is no doubt that a large part of the spread of the disease is due to the use of infected seed, but it is also an undeniable fact that new or secondary infections occur. This is supported by records of observations made in Porto Rico, Java, Hawaii and Cuba. It would be erroneous to assume that healthy cane showing new cases of yellow striping had in actuality the disease in such a dormant state as not to show its symptoms up to a period of several months or more. Tests as to dormancy were made, at the beginning of this work here, with seed pieces from cane which were in a not advanced stage of the disease. Portions of these canes were cut into pieces having one or two eyes each and placed in glass moist chambers for germination. The cane and glass chambers were sterilized to remove molds and bacteria. In forty-five trials, using cane from three different sources, not a single case was found where the symptoms of the disease were not observable in the unfolding leaves in the shoots of diseased seed. Diseased seed always produced diseased plants; in other words, if the disease is present in the cane it will show up at an early stage in

the leaves, by its characteristic symptoms. Further tests along this line were made by planting diseased seed pieces in sterilized and unsterilized soil, in pots. Here the results were the same only with a slightly higher accentuation of the symptoms in unsterilized soil due to the fact that the seed piece breaks down quicker by the aid of ferments and fungi which sometimes abound in such soils, thus aiding in the stunting and deterioration of the young buds. In the unsterilized soil the young shoots became, in addition to the yellow striping, speckled with a reddish tinge, and formed a shorter stem with the leaflets growing in more or less of whorls.

There is the possibility of the symptoms being so faint as to evade detection to the casual observer. The various symptoms of the disease on different varieties of cane have been described in previous publications, and it is plain that the disease can be recognized in all instances. However, the writer had under observation four plants in pots which showed only an occasional thin stripe of a darker green on a field of lighter green. These plants were kept up in good condition having applied to them a liberal amount of nitrate with frequent watering. The symptoms of yellow stripe always existed in these plants in the older canes but in a rather less pronounced form. The young shoots, however, which occassionally come up at the bases of these canes show the symptoms more distinctly. Other plants, diseased, and growing under the same condition close to the above show the disease very clearly and distinctly. On the other hand the same variety, Crystalina, is known to produce clearly distinct symptoms upon its becoming diseased in the field. The above four plants are kept for further observations. A degree of severity exists in the different fields and in individual cane plants. The severity of the disease depends, as has already been observed by others, on varietal resistence, length of time the disease is propagated in a given plant, and local conditions under which the cane is growing. In an infection experiment conducted in the greenhouse of the Insular Experiment Station, mention of which was made in last year's report, the "canker" stage was observed to have occurred in a cane in three months from the time when the first signs of the disease were noticed. This is contrary to views held by others, *i. e.*, that it takes a certain number of generations for the canker stage to arise. It was really the general unfavorable conditions for the growth of the plant, as it was grown for almost a year in a five-gallon tin can, that helped the canker stage to be shown up sooner.

INFECTION EXPERIMENTS.

I. Contact.

During the first part of this year experiments such as have been tried by others have been repeated in order to gain an intimate knowledge of the behavior of the disease. Healthy and diseased plants were planted together in the same pots; healthy and diseased seed pieces were split in half, and then a diseased half and a healthy half were fastened together and planted. There were no transmissions of the disease to the healthy plants. The healthy plant, though in contact with the diseased plant, has not contracted the disease. The healthy seed produced healthy shoots right alongside the diseased seed and shoots in the same pot. Healthy seed pieces were watered with water in which diseased cane was allowed to stay for some time. No infection occurred.

An experiment was made to find out if the disease could be transmitted through the roots. Diseased tissue was fastened onto the root eyes of healthy seed, so that the growing rootlet may come in contact with the cut surface of the diseased tissue. Eight of the healthy seed pieces germinated and the shoots were healthy. After four months in the pots two shoots of the healthy seed showed symptoms of yellow stripe. The experiment was repeated but gave negative results. The fact that the symptoms were belated in showing up would indicate that the two plants became infected through another source. There were diseased cane in the greenhouse.

Another experiment was made in the following manner: Healthy and diseased seed pieces were cut to contain three dormant buds each. The middle buds were carefully cut out with a sharp knife. Care was taken to make the cut at least one-half inch on all sides from the bud, in order to leave uninjured root eyes and some tissue for the growth of the bud. The buds from the healthy seed were then inserted in the diseased seed in the places of diseased buds and the buds of the diseased seed were inserted in the healthy seed. Practically all of the buds germinated and from the first no transfer of the disease was observed to have taken place either in the healthy seed with the diseased buds or in the healthy buds inserted in the diseased seed. The grafts thus made did not live long but the seed in which they were inserted developed sound shoots from their original two remaining buds. It was thought that by bringing in contact the cut ends of the vascular systems of diseased and healthy cane a transmission of the disease might take place. But no infection occurred in this experiment.

II. Juice.

Experiment 1.—On April 16, an experiment was made in the folowing manner: Five cane plants of about 8 months old, growing in five-gallon tin cans in the greenhouse of the Insular Experiment Station were examined and found free from any symptoms of yellow-stripe disease. Each of these plants consisted of one single stalk of about one inch in diameter and averaging about three feet in height. At the bases of each were one or more shoots of about six inches in height. These shoots also were free from yellow-stripe disease symptoms. The five stalks were cut back leaving stumps of about four inches above ground, the shoots were left as they were. Juice from a yellow-striped piece of cane was pressed out and injected, with a hypodermic needle, into the stumps near the surface of the ground. On April 28 typical symptoms of yellow stripe was observed in the lower parts and along the mid ribs of the central leaves of two shoots in two out of the five pots. At first only a few, larger, light green, narrow areas were noticed; later these light green areas spread all over the leaves and they became patterned with short alternating light-green and green stripes. In one of the two pots which showed infection on the 28th of April there were two shoots at the base of the old stalk but only one shoot showed infection on that date; however, about a week later the other shoot became infected. In three months the infected stalks have become more or less shrunken at the internodes and showed typical cases of the "canker" stage. The other three plants remained free from the disease throughout the experiment which lasted ten months. In this and later experiments the positions of the plants were noted and they were kept in the original places throughout.

The Position of Plants in Experiment 1.

	Plants inoculated April 16				
	No 1	No 2	No 3	No 4	No 5
April 28	free	diseased	free	diseased	free

Experiment 2.—On May 1 a similar experiment was made in the same greenhouse with similar plants. Twenty plants were inoculated with juice from diseased cane and 20 were left uninoculated as checks On May 14 two of the inoculated plants showed the symptoms of the yellow stripe disease. These plants are marked "D" in the next table.

The positions of the pots in this experiment were thus:

Bench 1:										
Inoculated	1	2	3	4	5	6	7	8	9	10D
Check	1	2	3	4	5	6	7	8	9	10
Bench 2.										
Inoculated	1	2	3	4D	5	6	7	8	9	10
Check	1	2	3	4	5	6	7	8	9	10

Experiment 3.—On the same date as the last experiment 10 plants were cut back only a little above the growing point, 5 of these were inoculated in the cut surface of the top by injecting diseased juice with a hypodermic needle, and 5 were left as checks. All of these have remained free from the disease.

Experiment 4.—On May 2, 25 healthy stools about three months old were transplanted from the field to the greenhouse in pots. The plants were cut back as in the first two experiments and 8 of these were inoculated with diseased juice and tissue; that is, in addition to the injection of juice, pieces of diseased cane were forced into small holes in the stems. All 25 plants remained free up to October when one of the checks developed the yellow-stripe disease symptoms. It must be stated that the four plants which developed the disease in the first experiments were of a lot of cane which were more mature than the last 25 plants. In order to test this point 18 seed pieces of mature Crystalina cane were cut to one or two eyes, 12 of these were inoculated near the base of the bud, by boring a hole into the seed piece three-quarters inch deep and directly into it was pressed juice from diseased cane, and 6 were inoculated in the same way with healthy cane juice. All were planted in pots and placed in the greenhouse.

Experiment 6.—At the same time 35 Crystalina stools in a field that has just been cut were inoculated with juice in the stubble near the bases of sprouting buds. In both of these last two experiments not a single positive case developed. The plants in the pots were transplanted, after four months in the greenhouse, to an open field, and up to the present no signs of the disease have become visible.

NATURAL AND SECONDARY INFECTION.

Experiment 7.—During the time when the above experiments were made there has not come to the writer's notice a case of second-

ary infection in the greenhouse, nor were there any such cases reported previously. This was rather strange as secondary infections were being picked up every two or three weeks in the adjacent cane fields. The greenhouse was not "insect proof." In order to make sure that secondary infections do occur in known healthy cane, 48 seed pieces from three healthy and mature Crystalina canes were planted in pots and placed in the greenhouse. After two months from germination three of the 48 showed symptoms of yellow-stripe disease. However, these three plants, together with a number of others of the same lot, were on the ground instead of on a bench.

Experiment 8.—So another series of 50 seed of three healthy white Otaheita cane were planted in pots and all were placed on clean benches. In about three months from germination one of two shoots from two separate seed pieces in the same pot became distinctly diseased.

Experiment 9.—Ten cane stools having been cut back and transplanted from the field to pots in the greenhouse have been allowed to grow for four months. These showed no signs of yellow-stripe disease during that period. At the end of four months they were cut back and allowed to sprout again. One shoot began to show yellow-stripe disease in the unfolding leaves, and in two weeks the entire stool became diseasd.

Experiment 10.—On May 15 five healthy stools in five pots were inoculated with diseased juice in the stalks near the root crowns. Up to September no symptoms of yellow-stripe disease have developed. During the first part of September the plants were all cut back and allowed to sprout up again, and two plants began to show the yellow-stripe disease in the central unfolding leaves of their shoots. It is assumed that these were secondary infections. It is of interest to note the development of the disease in one of these pots.

The position of the row of pots on the bench was thus: 1 2 3 4 5.

Numbers 2 and 5 became diseased. No. 5 had two small *cepas* of 5 to 7 shoots. Both *cepas* came out from two original buds on the sides of a single seed piece. At first one *cepa* showed the disease, the symptoms of yellow stripe appearing first in one shoot and then in another until all became visibly infected. In about three weeks the second *cepa* became diseased, and again a gradual spread of the disease from one shoot to another was observed. In all of these shoots

the central leaves always showed the symptoms first. It appears that the disease gradually communicates from one shoot to another through a common channel.

It is quite certain from observations made on healthy and diseased plants grown in close contact with one another, that mere surface contact does not transfer the disease to healthy plants. In the greenhouse a row of 10 diseased plants were placed alongside of a row of 10 healthy plants, allowing for contact between the healthy and diseased leaves, and not a single case of new infection resulted. However, during the late part of the summer a healthy plant which was adjacent to a diseased one in the greenhouse became diseased. This is the first case of its kind in the greenhouse, its occurrence should rather be layed to an outside agent rather than to its being close to a diseased plant.

The occurrence of yellow stripe in the greenhouse has been in all features similar to the way it works in the field. It attacks the young shoots and it is sporadic in location, it picks out a plant here and there only and there is not a general spread taking in complete areas. In the field a new infection may sometimes be observed on large cane, but from personal and close watch of the plants in the greenhouse secondary infection on more or less grown cane has not been seen.

The following conclusions can be drawn from the above observations; first that healthy cane from healthy seed became infected with the yellow-stripe disease; and secondly that the disease has been transferred artificially to healthy plants in four cases at least. It should be observed that in both, Nos. 1 and 2 experiments, the disease showed up in about two weeks from inoculation and there were no other new infections in the other plants in the greenhouse at that time. However, the exact method to insure takes is not known as yet. The prevailing idea that insects are the carriers of this disease is highly plausible, but the writer has not taken up this phase of the problem.

HISTOLOGICAL STUDIES.

Histological studies of yellow-striped cane were made with the view to determine if possible in what way the disease affects the tissue of the host. A search for abnormalities in the interior of the cane stalk and leaves of diseased plants was made. Tissue from dis-

eased mature cane stalks, from underground parts, from growing points and from leaves were cut with a sharp razor free hand and with the microtome. In studying microscopic sections of the outer cankered tissues of yellow-striped cane it was noticed that sometimes the parenchyma as well as collenchyma cells of the discolored areas possess very distinct, single, spherical, darkly colored and dense protoplasmic bodies. At first glance these resemble spore bodies of some organism. (Fig. 1 *a, b.*) These bodies were also found in the centre of diseased cane. In searching in the tissues of non-yellow striped cane it was found that these bodies also exist in parenchyma cells there. It was found in the base of a young stalk which was

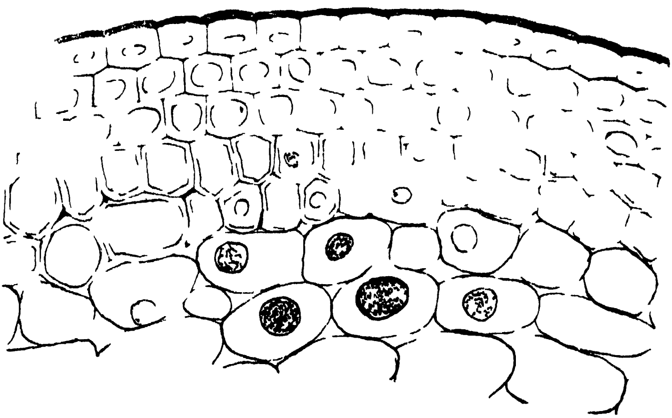

FIG. 1 *a*—Dense and deeply colored nuclei in cane tissue near the rind Drawing of a free hand section from a yellow stripe diseased stalk. (× 150.)

injured by a mechanical agent, it was found in the cells of roots of non-yellow striped cane and in the injured part of a stalk of cane of the same nature It seems clear enough that under certain conditions of growth the nuclei of certain cells become dense and deeply colored and give the appearance of dense granulation when influenced by an inhibitory or injurious factor. Sections of tissue containing the spherical bodies refered to above could not be permanently mounted in the usual way as alcohol dissolves those bodies. When placing a free hand section in alcohol the spherical bodies become vacuolated and ultimately disappear from view, only a very thin wall being left.

Paraffin sections of the uppermost nodes of yellow-striped and healthy cane were made. It was observed that a difference in the appearance of their respective tissues existed (Figs. 2, 3, and 4).

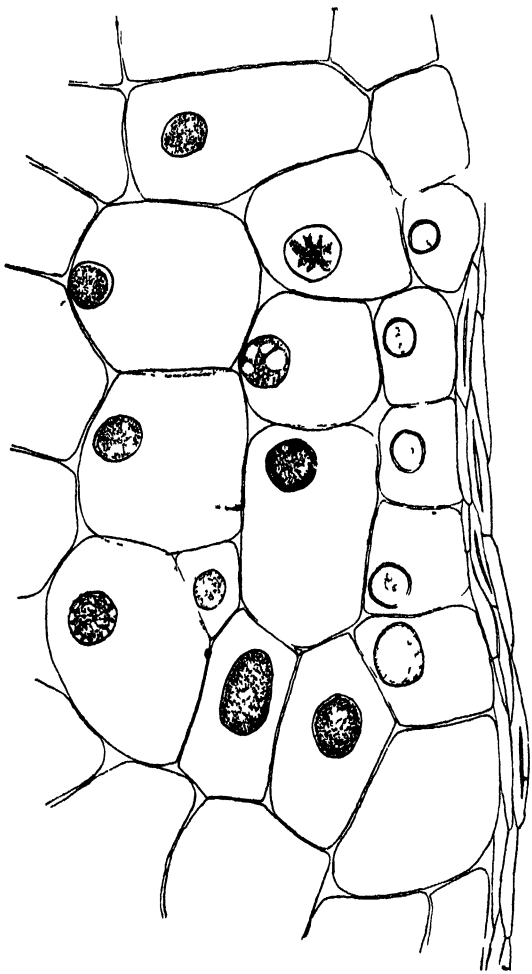

FIG. 1 *b*.—Drawing of similar bodies as in Fig. 1 *a*, in cells of non-yellow stripe but otherwise injured cane tissue. (× 250.)

In the diseased tissues some of the parenchyma cells between the fibro-vascular bundles were filled with a protoplasm which was dense and finely granulated, the bundles showed apparently the same sub-

stance in the sieve tubes and vessels,[1] while in the cells of the healthy cane the fibro-vascular bundles were free and the parenchyma between the bundles contained scattered and coarser granules. The last named are common in cut and exposed portions of young growing parts of cane.

Leaves of about the same age of healthy and yellow-striped cane were studied. Figures 5 and 6 show a striking difference in the appearance of the two. The healthy leaf in cross section shows no abnormality except slight shrinkage; in the diseased leaf some of

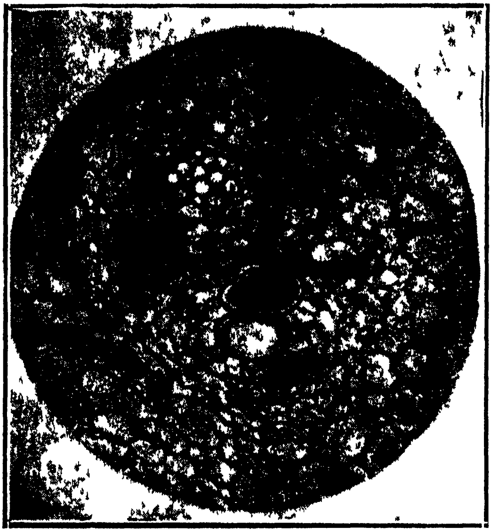

FIG. 2.—Photograph of a vascular bundle from near the growing point of yellow-stripe diseased cane, showing the finely granular substance in the vessels. (×50.)

the epidermal cells, especially near the stomata, and some internal cells show dense contents which is colored slightly brown, and which is similar in appearance to the abnormalities found in the cells of the cane stem It seems that a foreign plasmodium-like substance is apparently present in the cells of the yellow-striped cane leaf and stem tissue.

[1] The writer has of late seen specimens of cane affected with gum disease due to *Bacterium vascularum* This disease is distinctly different from the yellow-stripe disease, the gum of the former is yellow and full of bacteria which are easily cultured No slimy exudation occurs in yellow stripe disease

Further research along this line revealed the presence of the above plasmic substance more constantly and in a more defined form in "cankered" cane stalks. In investigating the histology of "cankered" cane a feature, which has not been mentioned before in the literature on the subject, has been noticed. Cankers have been characterized as exterior symptoms consisting of a few outer layers of

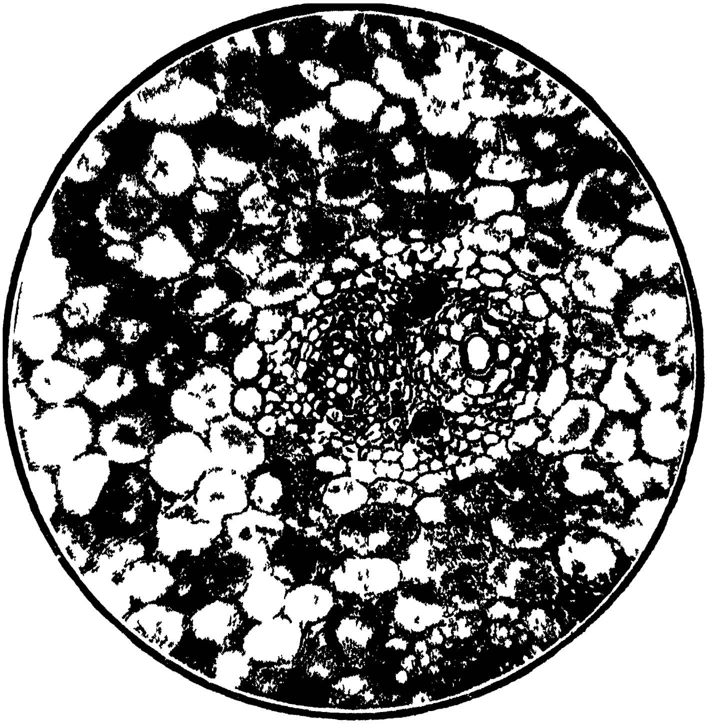

FIG 3.—Photograph of a cross section through a growing point of yellow stripe diseased cane. Note the character of the parenchyma cells and compare with Fig. 4.

deteriorated cells, but in reality one may find separate and distinct pockets of brown to reddish-brown tissue deep in the interior throughout cankered cane. More often such a discolored region may be found in the form of a short streak, several centimeters in length, usually very close to the rind of the stalk, but these streaks are not always exposed as they are found even where no breaking of the outermost layers of cells has taken place. Together with these dis-

tinctly brownish-colored areas there may also be present in the interior of stalks small longitudinal and light-colored areas where the parenchyma cells have entirely collapsed and leaving an empty cavity of a millimeter or more in width and of variable length. Microscopic sections of the discolored areas in yellow-striped cane stalks show that some parenchyma cells are full of a more or less

FIG 4 —Photograph of a cross section through a growing point of a healthy cane stalk (× 50)

hardened or compact, densely but finely granulated, and slightly browned plasma. (Fig. 7) Usually there are small groups of a few cells thus filled, but it is not uncommon to find only a single cell (Fig 8), full of the granular material while the surrounding cells only show a slight brownish discoloration in their walls. This phenomenon is common in older portions of more or less full-grown cankered cane, especially where an alteration in color exists in the

stem tissue. It has also been observed in leaf sheaths of yellow-stripe diseased cane. Here it is found in slightly depressed areas on the inner side of apparently uninjured leaf sheaths. It seems that the

FIGS. 5 AND 6.—Upper figure is a photograph of a cross section through a yellow stripe diseased cane leaf. The lower figure is a photograph of a cross section through a healthy cane leaf. (× 100.)

plugging of parenchyma cells in this manner is a diagnostic feature peculiar to yellow-stripe disease.

Free hand sections and sections from tissue which was fixed and

killed and imbedded in paraffine, from internal portions of cankered cane, were treated in the usual way, *i. e.*, dehydrated with alcohol and cleared with xylol. The cells which contained the dense and finely granulated substance did not lose it in the process of mounting.

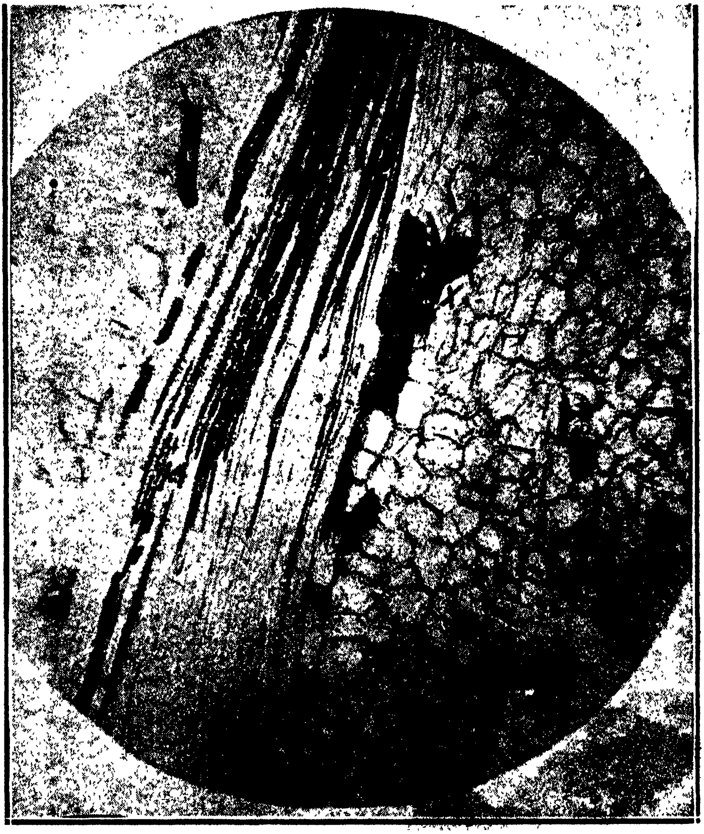

FIG. 7.—Photograph of a longitudinal section through a node of yellow-stripe diseased and cankered cane, showing a group of plasma-filled cells at X. (× 50.)

In examining these sections with the microscope it is at once apparent that the granular substance is made up of a mass of small hyaline bodies more or less uniform in size. However, their exact size and form could not be ascertained, due to the fact that the whole mass is in the form of a compact plasma. The hyaline bodies

which are dotted throughout the mass are less than one micron in length in sections from freshly cut cankered cane. They more nearly resemble nuclear granules in a mass of cytoplasm. They are less clearly defined than masses of bacteria

Early attempts to induce growth development in agar from the above plasma-filled cells have failed. It was thought advisable to observe the condition of cankered cane in more than one stage.

FIG 8—Photograph of a section through an interior canker of yellow stripe diseased cane, showing in the center and near the lower left hand corner single cells filled with finely granular plasma (× 250)

Therefore such cane was collected from three different parts of the Island, south coast, north coast, and northeast section. The local and scattered plasma-filled cells were found in the cane from the three parts mentioned and in the varieties Rayada, Cavengerie or red cane and other kinds. In growing cane the condition of the plasma-filled cells were similar in all canes examined. Some of the cankered cane was kept in a covered chamber for two months, so that the cane

became devitalized and yet not much dried out. Free hand sections of this material showed the granular plasma material in the parenchyma cells in the same proportion as in freshly cut cane, but the

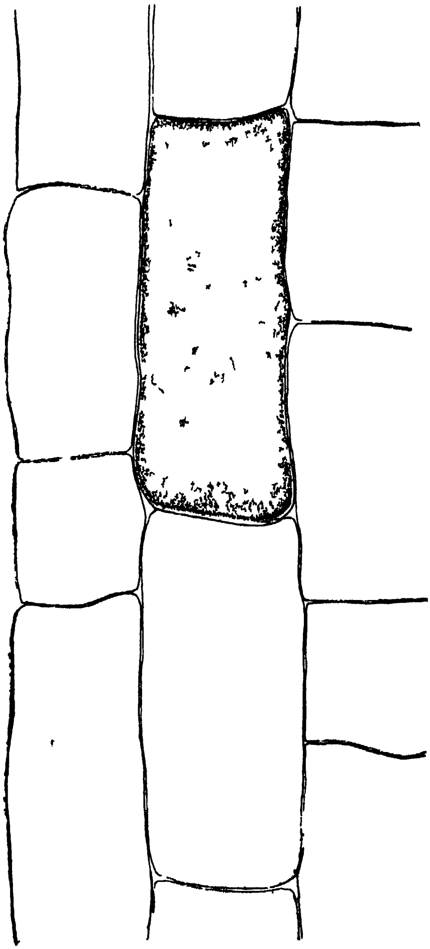

FIG. 9.—Camera lucida drawing of a plasma-filled cell in an internally discolored area in yellow-stripe diseased cane stalk. (× 333.)

granules in the former were more distinct, irregular in form, elongated and somewhat larger. In addition rotary movement of the individual minute bodies within the host cells was distinctly notice-

able. It appeared that growth or a separation into more distinct individuals took place. It was very clear from the material at hand that the compact plasma in the cells of freshly cut cankered cane were in every way similar in appearance and distribution to the plasma in the cells which were seen in the more devitalized cane, only that in the latter more distinctness was observable. However, it was felt that sugar-cane treated in this manner is bound to become overrun with microorganisms and so more cankered cane was obtained, sterilized in bichloride of mercury and kept in the moist chamber for daily observation. It was found that in the course of two days some

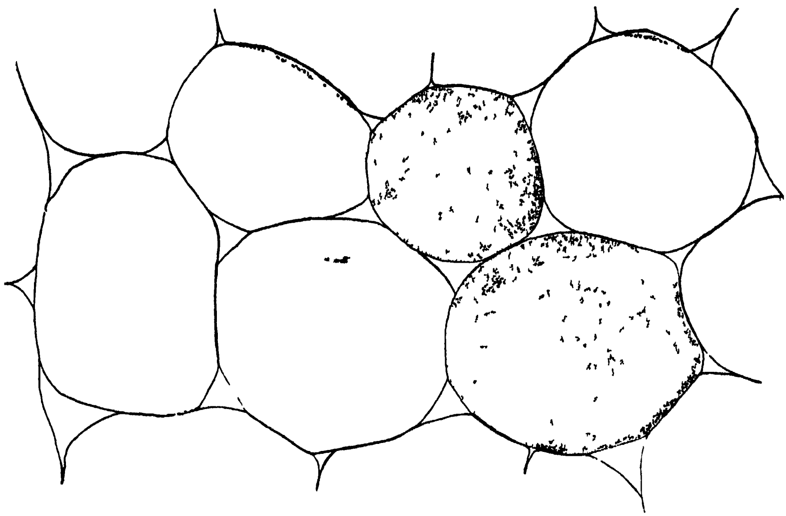

FIG. 10.—Same as in Fig. 9, in cross section. (× 333.)

cankered cane showed a greater distinctness in the granulation of the characteristic plasma-filled cells, and that after eight days motility was observed in the plasma mass. As to the exact nature of this organism in the cankered cane cells nothing more definite can be said until more data is obtained in the process of investigation.

In cane otherwise diseased or injured by borers or fungi a reddish discoloration usually is found, but it is more or less continuous and is confined more to the vascular bundles. Such bundles often contain a homogeneous gummy substance which is not at all like the substance in cankered cane parenchyma cells. Discoloration of

parenchyma cells in non-yellow striped cane may also occur but the discoloration is not of the same character as in yellow-stripe disease tissue. In cane diseased because of an invasion of fungi or other destructive agents the discoloration is more confined to the phloem and vessels and to the cell walls of parenchyma. A red phloem and gummed vessels are signs of wilt and decay due to fungi, bacteria, insects or mechanical injury. A continuous cavity in the pith or center of the stalk is a common effect of fungus invasion.

Further work is being done and planned with the view to clear up some of the phases of the problem of yellow-stripe disease.

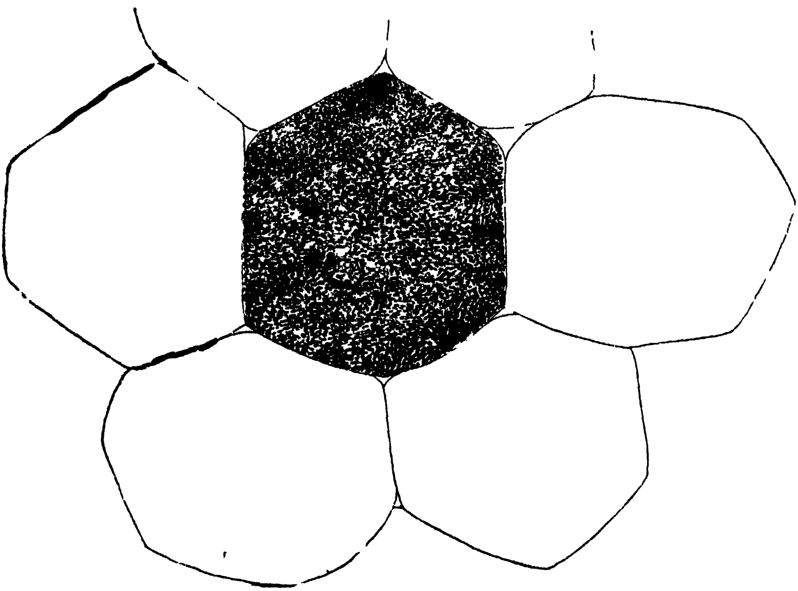

FIG. 11.—Drawing of a section of yellow-stripe diseased cane tissue two months after the cane was cut. (× 400.)

From a study of the internal structure of cankered cane it is clear that actual deterioration and breaking down of cells in the interior of cane in an advanced stage of the yellow-stripe disease takes place. This effect is due to no other cause than to the destructive action of the infective substance of yellow-stripe disease, as there is apparently no connection between these interior sick cells and other outside mechanical or organized agencies. Furthermore, this substance, resembling a *Plasmodium*, in some of the interior cells was found to be constantly associated with yellow-stripe cane in an advanced stage of disease.

INSECTS AND MOTTLING DISEASE.

By E. GRAYWOOD SMYTH, Chief, Division of Entomology.

The fact has been brought out by Professor Earle, in a preceding page, that most previous investigators of the sugar-cane mottling (or "yellow stripe") disease, notably in Java and Hawaii, have dealt with it as an inheritable bud variation and have failed to recognize its infectious nature, or at least to consider it as an important factor from an economic standpoint. Even in Porto Rico the infectious character of the disease was not recognized until the latter part of 1917. It is not surprising, therefore, that few attempts have been made, previous to the present work, to demonstrate a possible connection between insect attack and secondary infection with mottling disease.

The laboratory experiments detailed in this report were started in the spring of 1918, but had been preceded by a considerable amount of field work, made in the districts where the injury from mottling disease was most acute, in attempt to ascertain what insects might be concerned in the spread of the epidemic. In the experiments, four successful inoculations by insects have resulted, to date, while no control plants have become diseased, which would seem to fasten the responsibility, in these cases at least, upon the insects as carriers of the virus. It is felt, however, desirable to obtain duplications of the few positive results before conclusion may be safely drawn that insects are a principle means of communicating the disease.[1]

The idea that insects might carry the disease in Porto Rico found its origin in the knowledge of a number of unique, well-established facts:

1. Mottling disease is spread not alone by planting infected "seed," but may easily communicate itself to plants germinated from healthy cuttings. Experimental evidence tends to show that this spread of infection takes place neither through the soil nor by physical contact.

2. Such natural agencies of spread of disease as wind and surface water cannot account for the equal and general spread of mottling disease in all directions from infected to healthy plants.

[1] **Since the above was written, two additional plants have become mottled (diseased) as result of the attack of virus-bearing *Stenocranus saccharivorus*, and three others have shown positive secondary infection (inoculation) in cages containing both cane-fly and yellow aphis. No control plants have yet become diseased.**

3. Secondary infection is by no means confined to the plants immediately adjacent to diseased plants, but may occur on isolated plants at considerable distance from the seat of infection.

4. The rate of spread varies greatly with the season, not apparently in conformity with any seasonal abundance of wind or rainfall, nor with the amount of irrigation or cultivation, but in possible (if not probable) conformity with the seasonal abundance of certain insect pests.

5. Some very similar diseases of other cultivated plants, notably those known as virus diseases (such as mosaic diseases, spinach blight and sugar-beet curly-leaf) have been proven to be carried by insects; and in the case of some of them there has been found no other means of communicating the disease than by insects.

6. The two classes of insects proven to act most commonly as vectors of virus diseases—the leafhoppers and the plant-lice—are well represented among sugar-cane pests, and are often abundant in cane fields of the Island.

The accompanying tables (Tables I and II) give the names and hosts of a number of plant diseases occurring in the States that have proved to be transmitted, at least in part, by insects. An attempt has been made to show in these tables what characteristics the cane mottling disease has in common with other insect-borne diseases, and in what important details it differs from one or another of them.

FIELD EVIDENCE IN SUPPORT OF INSECT TRANSMISSION.

From such data as has been accumulated from field trips over the Island, it appears that there is no single species of cane-infesting insect or mite sufficiently common and prevalent in all districts, and at all seasons, where the disease is present and spreading, to account for the very general "run" of epidemic that has occurred.

If it shall later develope that several insects are concerned in the spread of the disease—and the results of our experiments to date lead to that belief—then we may possibly attribute the spread of the epidemic to one or another prevalent pest in each district where spread has been in progress. For instance, during periods of most rapid spread in the Guánica and Ponce districts, the yellow thrips has been the prevailing cane pest, and in fact the only one present in large numbers on both young and mature cane, and therefore the only one which might account for wholesale secondary infection in both young and mature cane. Rapid spread of mottling disease observed on numerous occasions in the Arecibo section might have been

blamed upon the green leafhopper, which occurred in all fields, particularly of young cane. On some occasions, local rapid spread of the disease has been observed to occur simultaneously with abundance of the yellow cane aphis, and this has seemed at the time significant. The spread of mottling disease in fields of the experiment station at Río Piedras has occurred usually at times when there was considerable cane-fly present in the fields, but no other cane pest that seemed to be able to account for the spread.

In the following paragraphs will be discussed briefly the cane insects which may be suspected of having possible connection with spread of the mottling disease, from a judgment based purely upon field observations.

Cane Insects as Possible Carriers of Mottling Disease.

THE YELLOW CANE THRIPS (*Frankliniella* sp.).

This small thrips has been observed for the past two years to be very abundant on young to half-grown sugar cane in fields on the south coast, in the Guánica and Ponce districts. It is most prevalent in the winter season, which is the time during which spread of the disease is most rapid. It is the only cane pest of those districts that has been found universally present, in large numbers, in both young and mature cane, being considerably more abundant, however, in the young cane. The ratio of its numbers in young and mature cane bears, in fact, a striking similarity to the proportion of secondary infection in young and mature cane. These thrips lay their eggs in the cane leaves, and breed in large numbers between the terminal, young, unfurled leaves, where their attack scarifies the leaf surface along the midrib, near the base of leaf, causing white scars that later turn brown. Young plants two to three feet in height often bear dozens of the thrips among their terminal leaves, which are not very visible except by tearing open the terminal bud; and it has been noted that the first evidence of mottling on a young plant usually occurs near bases of the terminal leaves in the region showing attack by this thrips.

This insect has not been noticed in abundance in other parts of the Island, though on one occasion it was found in young canes in a field at Río Piedras, during a dry spell, which indicates that it may also occur at other points along the north coast at some seasons. The adults are strong fliers, and could spread rapidly to other parts of a field from a few infected canes. Such search as has been made

TABLE

A SUMMARY OF OUR KNOWLEDGE OF INSECT-BORNE

Name of Disease	Principal Economic Hosts	Other or Wild Host Plants	Nature of Disease
1. Hawaiian Cane "Root Disease" (*Ithyphallus coralloides*).	Sugar cane...........	Lantana and other roots.	Fungus.....
2. White Pine Blister Rust (*Cronartium ribicola*)	5-leaved pines (18 spicies).	*Ribes* spp............	Fungus.....
3. Chestnut Blight (*Endothia parasitica*).	Chestnuts and chinquepin.	....	Fungus.....
4. Currant Stem Blight (*Botryosphaeria ribis*).	Currant and gooseberry.	Wild spicies of Ribes	Fungus.....
5. Tree-cricket Canker (*Leptosphaeria coniotherium*).	Raspberry ("Cane blight").	Apple, rose and elm.	Fungus.....
6. Apple Bitter-rot (*Glomerella cingulata*).	Apple, pear, peach, grape, quince.	Citrus, cocoa, coffee, mango, etc.	Fungus.....
7. Tomato Leaf-spot (*Septoria lycopersici*). (2)	Tomato.............	....	Fungus.....
8. Carnation Bud-rot (*Sporotrichum poae*).	Carnation............	June grass (*Poa pratensis*).	Fungus.....
9. Internal Disease of Cotton Bolls (4 undetermined fungi).	Cotton...............	Over 15 plants in 7 families.	Fungus.....
10. Fire Blight (*Bacillus amylovorus*)	Pear, quince, apple, apricot.	....	Bacterial...
11. Bacterial Wilt of Cucurbits (*Bacillus tracheiphilus*).	Cucumber, squash, melon, gourd.	Wild cucurbits.......	Bacterial...
12. Sugar Beet Curly-top....................	Sugar beet...........	14 known plants in 8 families.	Virus.......
13. Spinach Blight...........................	Spinach.............	Not yet determined..	Virus.......
14. Tobacco Mosaic Disease.....	Tobacco, tomato, pepper, petunia.	*N. rustica*, Jimson weed, and *Hyoscyamus niger*.	Virus.......
15. Potato Mosaic Disease	Irish potato..........	....	Virus.......
16. Cucumber Mosaic Disease................	Cucumber, pumpkin, squash cantaloupe	Gourd................	Virus.......
17. Potato Hopperburn (4).....................	Irish potato, apple, raspberry.	Dahlia and box-elder	(?)..........
18. Sugar Cane Mottling Disease............	Sugar cane, corn?, rice?, millet?	Sorghum, foxtail, crabgrass and Panicum. (5)	Virus (?)...

(*) A continuation will be found in Table II, following. These data have been taken from such sources as were available to the writer, and an attempt was made to make them as complete as possible, for purposes of comparison. The arrangement of the diseases is one of convenience only. A bibliography of the more important writings on insect transmission of plant diseases will be found at the end of this article, on page 112. The vacant spaces and question marks, in this table, serve to show how imperfect is our knowledge of the entire subject of insect transmission of plant diseases, and how great the need of research work along this line to aid in solving important problems of disease control. The deficiency of results from past endeavors to demonstrate insect transmission of disease shows, furthermore, how faulty is our system of technical training as regards a proper appreciation of the close co-ordination of pathology and entomology.

(1) Manner of transmission of the spores or virus by insects concerned. By the term cyclical is meant, substantial proof that the inoculum of disease, taken internally, must un-

I. (*)

DISEASES OF PLANTS OCCURRING IN AMERICA.

Proven Insect Transmitters	Insect Carriers of Viable Spores	Probable or Suspected Insect Carriers	Mechanical or Cyclical (1)	Externally or by Ingestion (1)	Disease
....	Sarcophagid and Muscid flies.	Ants; a beetle; sow-bugs; earwigs.	Mechanical	Both....	1
(Urediniospores) Lepidop. larvae; rose beetle; ants; stink-bugs; a weevil.	Any insect coming in contact with spores.	(Aeciospores) *Porthetria dispar* and *Pissodes.*	Mechanical	Probably both	2
....	Any insect coming in contact with spores.	*Leptostylus maculata*, a beetle.	Mechanical	Both....	3
....	....	*Psenocerus supernotatus*, a beetle.	Mechanical	(?)......	4
Œcanthus niveus; Œ. angustipennis.	Same	*Œ nigricornis: Œ. exclamationis;* bees to the fruit.	Mechanical	Both....	5
Pomace flies (*Drosophilidae*).	Same	Tree-crickets; fruit frequenting insects.	Mechanical	Both....	6
....	Potato beetle; tomato horn-worm; a lady-beetle. (2)	Flea-beetles and leaf frequenting insects.	Mechanical	Both....	7
....	....	A Tarsonemid mite. *Pediculopsis graminum.*	(?)	(?)......	8
Dysdercus spp., *Nezara, Leptoglossus, Phthia.*	Same	....	Mechanical (?)	(?)......	9
Scolytus rugulosus; bees; aphids; *Lygus pratensis; Empoasco mali.*	Same	*Ceresa bubalis;* wasps, flies, ants, thrips, borers, tree-crickets, Elateridae	Probably mechanical	Both....	10
Diabrotica vittata and *D. duodecimo punctata.*	Same	....	Mechanical; doubtfully cyclical	Both....	11
Eutettix tenella	....	No other	Apparently cyclical	Ingestion	12
Macrosiphum solanifoliae; Rhopalosiphum persicae; Aphis rumicis; Lygus pratensis.	....	....	Possibly both (3)	Apparently both	13
Rhopalosiphum persicae; Macrosiphum tabaci.	....	Flea-beetles; some sucking insects.	(?)	(?)......	14
Rhopalosiphum persicae and another aphid.	....	....	(?)	(?)......	15
Aphis gossypii............	....	....	(?)	(?)......	16
Empoasco mali............	....	No other......	(?)	(?)......	17
W. I. cane-fly; leaf scale; yellow aphis; mealybug. (6).	....	Yellow cane thrips; shot-hole borer.	(?)	(?)......	18

dergo a period of incubation before it becomes infectious to a healthy plant, which is taken as evidence that it undergoes some change, perhaps cyclical, within the body of insect.

(2) The same insects are reported also as carrying the spores of early blight, *Alternaria solani*, that attacks also potato.

(3) The fact that the virus of this disease may be inherited through several generations of the aphid gives grounds for belief that the transmission is of a cyclical nature.

(4) It has not yet been determined, according to the author of the investigations, whether this malady is a specific disease, though it gives evidence of being one.

(5) The list of host plants of the cane mottling disease is taken from the bulletin by E. W. Brandes, not from the present publication.

(6) As noted in the text, the apparent transmissions resulting from attack of the four insects here listed are considered to require to be experimentally repeated before the evidence against these insects is conclusive.

TABLE

A SUMMARY OF OUR KNOWLEDGE OF

(Continuation

Disease	Length of time insect can carry inoculum	Infectivity inheritable in insect	Other means of natural dissemination
1 Hawaiian Cane "Root Disease"...	6 to 18 hours internally.	No....	Mechanical spread of mycelium.
2 White Pine Blister Rust...........	(?)......................	No....	Wind; rain; animals; birds; nursery stock.
3 Chestnut Blight....................	(?)......................	No....	Wind; rain; animals; birds; nursery stock.
4 Currant Stem Blight...............	(?)......................	No....	Wind.....................
5 Tree-cricket Canker.	Over 20 days externally; 6½ hours to 5 days internally.	No....	(?)........................
6 Apple Bitter-rot..................	(?)......................	No....	Wind and rain from cankers and mummies.
7 Tomato Leaf-spot	(?)......................	No....	Hands of pickers; wind and rain.
8 Carnation Bud rot	(?)......................	(?)....	(?) ....
9 Internal Disease of Cotton Bolls..	(?)......................	(?)...	None known ....
10 Fire Blight.	(?)	(?)....	Rain; unsterilized tools; nursery stock; infected prunings
11 Bacterial wilt of Cucurbits	Over winter............	No...	Rarely by root contact..
12 Sugar Beet Curly-top.............	Over 111 days	No....	None ....
13 Spinach Blight.....	For 4 successive generations.	Yes...	None known..... ....
14 Tobacco Mosaic Disease...........	(?).....	(?)....	Hands of pickers; contact of leaves
15 Potato Mosaic Disease.............	(?)......................	(?)....	Mosaic tubers; through the soil
16 Cucumber Mosaic Disease	(?)......................	(?)....	None known.............
17 Potato Hopperburn.	(?)......................	(?)....	Apparently none ....
18 Sugar-cane Mottling Disease	(?).....	(?) ...	Cuttings..... ....

II.

INSECT-BORNE DISEASES OF PLANTS.

from Table I.)

Successful methods of artificial inoculation	Disease transmitted through soil	Carried through the seed	Transmitted by vegetative reproduction	Infectious by contact or handling	Disease
By mycelium only	Yes	No	Principally	No	1
By spore germination	No	No	No	Urediniospores on currant.	2
By spore germination	No	No	No	No	3
By spore germination	No	No	By cuttings		4
With the excrement of tree-crickets.	No	No	No	No	5
By spore germination	No	No	No	By spore contamination.	6
By spore germination	No	No	No	Very	7
None performed	No	(?)	(?)	(?)	8
None	No	No	No	No	9
Spraying or rubbing with spore-laden material.	No	No	No	Rarely	10
Needle pricks; water suspension of spores poured over soil.	Rarely, when roots are injured.	No	No	No	11
By grafting; no other	No	No	Yes	No	12
Needle pricks; juice of crushed virus-bearing aphids.	No	No	Would be	Yes, if tissue is crushed.	13
Needle pricks; rubbing or spraying with virus	Rarely, when roots are injured.	No	Would be	Very	14
Injection of or rubbing with virus.	Yes	(?)	Principally	Yes, if tissue is crushed.	15
Needle injections; contact of virus with wounds.	No	(?)	Would be	Yes, if tissue is crushed.	16
None	No	No.	No	No	17
(See preceding articles by the pathologists).	No	(?)	Principally	No	18

has failed to reveal the presence of this species on "malojillo" (*Eriochloa subglabra*), the common grass of the cane fields, but it is altogether probable that the species may breed in some wild grasses as well as in cane, and this fact will be determined.

THE WEST INDIAN CANE-FLY (*Stenocranus saccharivorus* Westw.).

This green plant-hopper is very generally distributed over the Island in the cane fields, but seems never to become abundant, due, it is believed, to the activity of its natural enemies. These consist principally of three parasites (a Stylopid, a Mymarid and a Dryinid) and a common grass lizard (*Anolis pulchellus*). Because of the close relationship of this insect to the sugar-cane leafhopper of Hawaii (*Perkinsiella saccharicida* Kirk.), which has been accused of causing the destructive rind disease to a great extent in those islands, it is plausible to believe that it might become a factor in the distribution of cane mottling disease in fields where it becomes fairly prevalent. That the cane-fly is capable of very great increase in numbers, and of correspondingly serious damage to cane, in situations where it is not kept in check by rain, high wind, and other natural elements of the weather in addition to its natural enemies, has been shown by its phenomenal increase in the experimental greenhouse of the experiment station, and in certain screen-covered breeding cages, where it has often literally covered the undersides of cane leaves, and caused by its copious secretion of honey-dew a growth of black mold that smothered the lower leaves of the plants. As a cane pest, it must be considered an element of great potential danger in connection with possible spread of mottling disease, if not from its own injuries to cane.

THE YELLOW SUGAR-CANE APHIS (*Sipha flava* Forbes).

This small insect is a source of danger, in connection with the spread of disease, not alone from the fact that it is quite prevalent and generally distributed in cane fields, and often becomes so abundant as to assume the proportions of an epidemic, but also from the fact that it is closely related to certain insects (also aphides) that are known to carry virus diseases in other plants. Such diseases, transmitted by aphides, are the tobacco mosaic, the spinach blight, and the potato mosaic. The yellow aphis has been found prevalent in a number of fields where mottling disease was present and spreading; but there have, at the same time, been fields subject to spread of the epidemic where the yellow aphis was not found; so

that indictment of this insect from field observations alone is not permissible.

THE GREEN SUGAR-CANE LEAFHOPPER (*Kolla similis* Walk.).

This bright green leafhopper, because of its prevalence in fields of young cane in nearly all parts of the Island, was one of the first to fall under suspicion. Its close relationship to the leafhoppers that transmit curly-leaf of sugar beets, and hopper-burn of potato, in the United States is added reason for placing it among the species worthy of investigation. In the laboratory this insect has been reared from egg to adult, generation after generation, on sugar cane, and the frequent finding of nymphs on sugar cane in the fields adds to the belief that it breeds on cane commonly, though perhaps to a greater extent on Para grass (*Panicum bardinode*) and "malojillo" (*Eriochloa subglabra*), its wild food plants.

The two facts which throw question on the possibility of this insect carrying the disease are: first, the fact that it occurs commonly only on cane under three feet high, and rarely on half-grown cane, but almost never on mature cane, whereas secondary infection may take place in cane of any age; and second, the fact that all experimental tests (and there have been more with this than with any other species) have failed to demonstrate its ability to carry the disease.

THE SUGAR-CANE SHOT-HOLE BORER (*Xyleborus* sp.).

This very small boring beetle was observed by the writer, two years ago, to be present and infesting the seed sections from which were sprouting some young canes in the Guánica district that were highly infected with mottling disease. It was stated by the field manager that the seed had come from healthy cane; and observation showed that there was no older mottled cane in immediate vicinity, though fields of mature cane at distances of a quarter to half mile from the young cane were considerably infected. As this insect is known to attack and bore into live standing cane, particularly when soured or unhealthy, it seems not improbable that adults migrating from mature mottled canes in cankered condition, and attacking the seed in the ground before or at time of germination, might easily carry the disease with them and transmit it to the sprouting young canes. Experience in other parts of the Island has shown seed-cane sections in sprouting condition to be very often infested with this pest, so the chance of the disease being thus caried may not be re-

mote. Laboratory tests with the insect have not yet been made. A closely related species of *Xyleborus* (*X. perforans* Woll.) has been accused of complicity in the spread of a sugar-cane disease in Trinidad (see Insect Life, Vol. V, page 51).

THE MEALYBUG.

Of this there are two species, *Pseudococcus calceolariae* Mask. and *Ps. sacchari* Ckll., which are almost indistinguishable except under a microscope, and are apparently about equally common. They attack mature cane on the stalk about the node, protected beneath the leaf sheaths, but on young cane are confined largely to the base of plant and the roots. As mature female mealybugs do not fly, and crawl but very little, they are wholly dependent upon foreign agency for their distribution. This takes place largely through the scattering of infested stalks or cane tops during the hauling, or from scattering by hand. Mealybugs may be carried also on floating fragments of infested cane on irrigation water. Birds may carry the young on their feet, but such dispersion is very limited. It is claimed that ants carry live mealybugs from plant to plant, and thus start new colonies, but this contention needs further corroboration. A field may become infested from insects that migrate upward onto young plants from the infested seed pieces, and is still more often infested from the stubble of the previous crop, or from grass or volunteer cane in the field that has harbored thousands of the mealybugs from the preceding crop. By any of the means here mentioned, mealybugs might be able to carry the mottling disease from a previous to a new crop, and even to spread it to some extent, if it may be shown that they are able to transmit the infective principle of this particular disease; but it is quite inconceivable that an insect so utterly dependent upon human agency for its spread, could be responsible for rapid spread of the disease in a field planted entirely to healthy seed, and in which a previous crop had not been seriously infected—conditions very frequently met with in connection with a study of the mottling disease.

THE CANE RUST-MITE (*Tarsonemus spinipes* Hirst).

This very minute white mite attacks principally the stalk and leaf sheaths, where it forms large clusters of very small, flat brown blisters, that give the plant tissue a scabby or scarred appearance. The mite infests new plants by migrating upward from the infested seed pieces. Its bionomics are little known, but it is possible that

the rust-mite may also be spread by attaching itself to winged insects that frequent the cane, which may carry it to new plants. This is a habit shared by many of the mite pests of plants. Altogether, however, what has been said of the mealybugs, in connection with their possible agency in the rapid spread of the mottling disease, may also be said of this pest. Its means of transportation are too limited to give it serious import in this connection.

THE SUGAR-CANE RED-SPIDER (*Oligonychus viridis?*)

This very small acarid pest of cane, while often abundant and doing damage to cane foliage in our greenhouse and in rearing cages, has not been noted as abundant at any point in the field, and is in fact rarely seen. Being a sucking insect, it may be regarded as a possible disease carrier when abundant. As its principal means of distribution are the wind and other insects, to which it attaches, and to some extent mechanical carriage on clothing or animals, there is probably small chance of its taking any part in a general and rapid spread of the disease.

THE CANE ROOT MITE (*Uropodus* sp.).

This pest was first noted in the Arecibo district more than three years ago when making studies of the sugar cane in connection with mottling disease, and has since been found abundantly at Río Piedras and in other districts. Its damage arises from its attack on the roots, which in some cases it tunnels and severs to a coniderable degree. Although diseased plants seem to be most badly attacked by it and the roots showing its injury are in many cases diseased and partly decayed, it has been found attacking also healthy roots, so in some cases is believed to be the primary cause of the root decay. What connection the root decay accompanying attack of this mite may have with the external symptoms which we know as mottling disease has not been fully worked out, but is the subject of investigation. This animal belongs to a group of mites which possess the habit of attaching themselves to beetles as a means of transportation and distribution.

THE FIRE-ANT (*Solenopsis geminata* Fabr.).

This is the commonest species of ant in the cane fields of Porto Rico, and attends all species of aphis, scale and mealybug. Some of these insects it even protects by building earthen shelters over the

colonies, when these latter occur on the stalk near the ground, and it will attack vigorously any intruder on the insect colonies. The possibility of this ant carrying a disease mechanically on its feet or body, as the gypsy moth larva carries the white pine blister rust or the Colorado potato beetle carries the early blight, is not to be ignored; yet until the mottling disease of sugar cane is proven to be caused by a definite spore-bearing organism capable of isolation and of causing reinfection of the disease in a healthy cane plant, the idea of ants carrying this particular disease need not be looked upon seriously.

CHEWING INSECTS.

What has just been said of the fire-ant, and of its possible ability to transmit the cane mottling disease, may as well be said of the majority of the so-called chewing insects, excepting only those which by habit may bodily leave the tissue of one plant and enter that of another, as does the shot-hole borer or the root mite. Of cane pests like the Lepidoptera that attack the plant only in the larval stage there seems, for the present at least, very remote possibility of the infective principle being transmitted from larva to adult and in turn to the egg and next generation larva, and by that means reaching healthy plants from diseased ones. The idea of Lepidoptera carrying a virus disease by any other means seems still more remote, as larvae seldom feed upon more than one plant, or migrate from plant to plant, between hatching and maturity.

Among leaf-feeders like the Orthoptera (grasshoppers and crickets) and certain Coleoptera (beetles), we have to consider not only the possible transfer of the virus, or inoculum, on the mouth parts, by which means it might be carried from plant to plant, but also the possibility of the ingestion of the infective principle and its later transfer to healthy plants with the excrement of the insect. There are plentiful records of the transfer by this means of spore-bearing diseases, but none to our knowledge of such diseases as do not bear definite sporing bodies.

One other element should be considered, namely, the fact that the chewing insects, though they include over fifty per cent of the cane pests, are very much fewer in numbers in cane fields than the smaller, sucking insects; and during the winter season one may often examine hundreds of cane plants, even in fields where mottling disease is present and spreading, without noting any evidence of the attack of leaf-chewers or stalk-borers. Thus it would seem

difficult to attribute a spread of disease, taking place in all parts of a field, to insects that are nowhere in evidence.

While such a generally prevalent pest of sugar cane as the *changa* (*Scapteriscus vicinus* Scud.) may easily fall under suspicion as a carrier of mottling disease, we cannot ignore the fact that the rapid spread of the disease has in no instance been found to coincide with the areas most heavily infested with *changa*, and in many fields of heavy soil where no *changa* was present the disease has spread alarmingly.

Experimental Methods Employed.

Some difficulties have been experienced in developing methods for confining insects upon living cane plants—upon large numbers of plants—in such manner as not to interfere with the natural growth of the plants nor to disturb their root systems. Our first experiments having demonstrated that the transference of the disease through insect attack takes place rarely, and only under very favorable conditions, it became plain that we must subject large numbers of plants to insect attack in order to entertain any hope of obtaining results. This rendered it impossible to use the sort of cloth-covered cages, placed over field-grown plants, that are usually employed in plant-disease transmission experiments. Other methods were therefore devised. The following four methods have proven satisfactory, for experiments with different kinds of insects or different ages of cane plants.

(*A*) Screen-covered cages 3 feet square and 6 feet high, placed over field-grown cane, one containing mottled plants and the others healthy cane. These are adaptable for the larger insects. A number of insects are introduced into a cage with mottled cane. At end of a determined period, which may vary from a few hours to a number of days, as many as possible of the insects are recaptured in the cage containing diseased cane, and transferred to one containing healthy cane, where they remain for another determined period of time. They are then removed from cage and the cane is watched, week after week, for appearance of mottling.

(*B*) Cages of same size as preceding, either screen or cloth covered, but containing both healthy and diseased cane. planted simultaneously. When cane has reached a desired height, insects of a given species are introduced, and the healthy cane is watched thereafter for appearance of disease.

(*C*) Insects collected on mottled cane in the field are transferred,

either individually or in numbers, onto single potted young cane plants, germinated under cover, in confinnement of glass lamp-chimneys or cylinders of fine wire screening, as the size of the insect may require. The healthy cane is subjected to attack for a determined interval of time, when the insects are removed and the cane transferred to the open field.

(*D*) Insects reared in confinement on mottled cane plants, or confined on mottled plants for a known length of time, are transferred to healthy young plants in confinement, as in preceding method.

Checks and Controls.

Throughout the course of the experiments there has been an effort to keep growing, side by side with test plants and under exactly similar conditions of growth, cane plants of the same age which were not subjected to attack of insects previously fed on mottled cane. These were the check plants, or controls, and were of three classes:

(*a*) Simple checks. Plants identical with test plants, but subjected to no artificial treatment whatever.

(*b*) Control plants which had introduced into cages with them, at same time that insects were introduced with test plants, portions of leaves of mottled cane bearing no insects. These were used usually as check on test plants with which it was necessary, or convenient, to introduce portions of the plant bearing the insects from mottled cane, and such controls were designed to show that infection had not resulted from the portions of mottled plant, but from the insects.

(*c*) Control plants having introduced into cages with them a number of insects equal to that introduced with the test plant and of same species of insect, but the insects collected from healthy and not from diseased cane.

In the earlier experiments, it was customary to grow only one or two checks, or controls, with each series of test plants; and a few series of test plants were, principally through oversight, unaccompanied by checks or controls. In the later experiments, however, greater accuracy was maintained in this regard, and a check plant, or control, was grown side by side with every test plant.

It is noteworthy that, while four distinct cane plants became infected with mottling disease in our experiments, apparently as result of insect transmission, no checks or controls became similarly infected. (See foot note on page 83.)

Two control plants did contract the disease, but only by secondary infection, after they had grown beside mottled plants in the field for periods of 3 and 3½ months.

SECONDARY INFECTION AMONG EXPERIMENTAL PLANTS.

As has been mentioned in preceding discussion, the mistifying feature connected with secondary infection is that it is not confined to the plants growing immediately adjacent to diseased plants, but may occur on isolated plants at some distance from the seat of infection. That the adjacent plants are, however, most apt to contract disease, or at least, to contract it first, seems fairly well established. In proof of this statement may be given our experience in the plots of experimental cane plants on the grounds of the experiment station.

As it has been our desire to prevent the disease from gaining a foothold in station fields, efforts have been made to avoid growing mottled canes outdoors, in exposed situations, for any length of time, where they might become a source of secondary infection. The first two canes that became infected with mottling in our insect transmission experiments were never transplanted to the field, as they gave evidence of infection prior to date of transplanting. The last two, however, were transplanted to field before attack of the disease became evident; and so it happened that they were allowed to remain, in diseased condition, among healthy plants for a period of three to four months. They were intentionally left, as it had seemed that secondary infection had ceased to occur at Río Piedras. As result of these two plants (Nos. 531 and 577), however, secondary infection did occur, the disease showing up simultaneously in two control plants (Nos. 531 *a* and 577 *a*) that were planted immediately adjacent to the test plants. The length of time required for secondary infection to become evident, after the date on which infection had appeared in the test plants, was three months in the one case and three and a half months in the other.

It may be remarked here that, five days after the secondary infection had appeared in these two check plants (on January 31st), both they and the two mottled test plants were transplanted to large cans in the green house, and 16 days later (on February 16th) the symptoms of disease appeared in another plant in the field, as result of secondary infection. This time it was a test plant that became mottled (No. 530), which had stood next to the mottled plant 531, but on opposite side of it, in the row, from the check plant (No. 531 *a*).

As for the insects present in the experimental plat that might have been responsible for the secondary infection, there have been rather few species, and none of them abundant. Some yellow aphis has been present and some cane-fly, and while the plants were still small the green leafhopper was very common. Presence of ants (*Solenopsis geminata*) and their earthen shelters about the roots also indicated that some mealybug was present. No other cane-feeding insect than these was seen on the plants. Of course, the mealybugs and yellow aphis originally infesting the plants had been transferred along with them to the field; but of these two, the yellow aphis had not multiplied on them, but had gradually disappeared.

Another matter worthy of note, in connection with a discussion of secondary infection, is the fact that no transmission of the disease to canes in the experimental plat has taken place in over a year, other than the three plants mentioned above, in spite of the fact that not ten paces from the plat is the greenhouse in which dozens of exposed mottled canes have been constantly growing. Both doors of greenhouse have been wide open on many occasions, a ventilator in the roof has been open nearly a foot, quite continuously, and the two ends of building are covered only with a screening of wide mesh (seven strands to the inch), leaving apertures large enough for the cane-fly, yellow aphis and red-spider, the three worst pests in the greenhouse, to pass with ease. It is difficult to see why these three pests, if capable of carrying the disease, should not have carried it from the greenhouse to the outdoor plat in a year's time.

The idea that ants may carry the mottling disease seems also to find poor substantiation from the fact that screened cages containing mottled canes have stood immediately adjacent to the experimental plat for more than a year and the ants have moved rather freely through the meshes of the screening; yet no secondary infection has taken place from this source. Within the greenhouse, mottled and healthy plants have on some occasions grown side by side in a pot or can for months, both infested with mealybug and equally attended by the ants, without any transference of the disease.

As has been stated by the pathologists, some secondary infection has taken place in the greenhouse, where over a hundred cane plants, mottled and healthy mixed, have been growing constantly; but this infection has seemed small, quite out of proportion with the great abundance of insects in the greenhouse, particularly of the three pests mentioned in a previous paragraph (the cane-fly, yellow aphis and red-spider).

RESULTS OF THE TRANSMISSION EXPERIMENTS.[1]

THE GREEN SUGAR-CANE LEAFHOPPER (*Kolla similis* Walk.).

The first experimental tests made with this leafhopper were by method A, the length of time during which the leafhoppers were confined on the mottled cane varying from a few hours to a week, and the number of individual hoppers employed varying from 4 to 39 (see Table III).

Two tests were made by method B, 48 adults being used in each instance (see Exps. 283 and 284 in Table IV).

By methods C and D, 91 plants were tested with this insect, using both nymphs and adults, the number of individuals employed per plant varying from 1 to 7. In some cases individuals confined on healthy plants were of the third and fourth generation that had fed almost continuously upon mottled cane.

The results of all experimental tests made with this leafhopper were negative.

TABLE III.

FIRST CAGE EXPERIMENTS WITH *KOLA SIMILIS* WALK.[2]

Date	No. of Adults	Period of Previous Feeding on Mottled Cane	Results
July 25	39	7½ hours	Negative.
" 24	14	1 day	"
" 18	21	2 days	"
" 22	4	3 "	"
" 26	10	3 "	"
" 22	9	4 "	"
" 15	8	6-7 "	"
" 16	30	7-8 "	"

Successful inoculations, none.

[1] In each case of infection with the mottling disease as result of attack by insects in confinement, the true presence of the mottling symptoms was verified by at least two other experts of the station staff in addiion to the writer, usually the director and one of the pathologists, Professor Earle or Mr. Matz.

[2] In these transmission experiments method A was used (see page 95,) and the leafhoppers remained on the healthy cane plants until they died or disappeared

TABLE IV.

EXPERIMENTS WITH *KOLLA SIMILIS* WALK.

Plant numbers	No. of test plants	No. of check plants	Date of confinement	Insects confined per plant	Days insects confined	Cane transplanted	Plants became diseased	Date disease appeared	Check plants diseased
157 to 161	5	2	January 10	1 Adult	4-10	February 3	None	....	None
176 & 177	2	1	" 10	1 "	17-31	" 15	"	....	"
216	1	1	" 20	1 "	12	" 17	"	....	"
217	1	0	" 31	1 Nymph	7	" 17	"	....	....
218 to 222	5	2	" 31	1 Adult	7	" 20	"	....	None
224	1	0	February 1	1 "	6	" 24	"	....	"
226	1	1	" 7	1 Nymph	17	" 24	"	....	....
227 to 230	4	2	" 7	1 Adult	17	" 24	"	....	None
239	1	0	" 7	1 Nymph	12	" 19	"	....	"
240 to 214	5	2	" 7	1 Adult	12-14	" 19 to March 14	"	....	....
255 to 258	4	0	" 19	1 Adult	21-22	March 14	None	....	None
259	1	0	" 20	2 Nymphs	21	" 14	"	....	....
267	1	0	" 22	5 "	20	" 14	"	....	....
268	1	0	" 23	1 Adult	19	" 15	"	....	....
269	1	0	" 23	7 Nymphs	19	" 15	"	....	....
270 & 271	2	1	" 24	1 Adult	19	(Both died)	....	....	....
272	1	1	" 24	3 Nymphs	19	March 15	None	....	None
274	1	0	" 24	5 "	19	(Died)	....	....	"
283 & 284	2	1	" 25	48 Adults	1 month	***	None	....	None
287 to 290	4	2	" 26	1 Adult	17	March 15	"	....	"
294	1	0	March 10	4 Adults	3	" 14	"	....	"
302 & 303	2	0	" ?	3 Nymphs	?	" 17	"	....	....
304	1	0	" ?	1 Nymph	?	" 17	"	....	....
312	1	1	" 14	4 Adults	16	June 2	"	....	....
315	1	1	" 14	2 "	43	April 29	"	....	None
338 to 343	6	0	" 17	1 Adult	43	" 29	"	....	"
341	1	0	" 14	2 Nymphs	43	" 29	"	....	....
361	1	0	" 31	2 Adults	24	" 29	"	....	....
362 to 369	8	0	" 31	1 Adult	24	" 29	"	....	....
370 to 373	4	0	" 31	1 Nymph	26	" 29	"	....	....
422	1	0	April 28	2 Nymphs	**	....	"	....	....
435 to 442	8	0	" 30	2 "	**	August 4	"	....	....
443	1	1	" 30	3 "	**	" 4	"	....	None
454 to 461	8	2	" 30	1 Adult	**	" 5	"	....	"
463	1	0	May 27	2 Nymphs	**	" 6	"	....	....
478	1	0	" 31	2 Adults	**	" ?	"	....	....
489 & 490	2	0	June 2	2 "	**	" 13	"	....	....
491	1	1	" 2	3 Nymphs	**	" 13	"	....	....
Total	93	22	....	....	....	....	None	....	None

* Plant died.

** The insects were not removed from these plants up to the time the latter were transplanted to field.

*** Tests made by method B.

THE WEST INDIAN CANE-FLY (*Stenocranus saccharivorus* Westw.).

Trials with this insect were made mostly by the last two methods, C and D, though two tests were made by using method A (Exp. Nos. 316 and 325) and four by method B (Exp. Nos. 506, 508, 510 and 512). A total of 87 tests was made, of which number only one test gave successful transmission. The plant that became infected, No. 377, was one of a series of three plants, each subjected, on March 31st, to attack of two adults taken from leaves of mottled cane in the greenhouse. The plant showed, by April 29, no apparent signs of mottling. On May 27, however, when next examined, it presented a very aggravated case of the disease, which must have become apparent very early in May.

TABLE V.

EXPERIMENTS WITH *STENOCRANUS SACCHARIVORUS* WESTW.

Plant numbers	No. of test plants	No. of controls	Date of Confining Insects	Insects Confined per Plant	Days Insects Confined	Date Plant put into Field	Test Plants Became Mottled	Date Mottling Appeared	Controls Became Mottled	Date Mottling Appeared on Controls
183 - 186..	4	2	1/20	1 adult....................	11+	2/17	None	......	None	......
187 - 188..	2	1	"	2 nymphs................	28	2/17	"	......	"	......
189 - 190..	2	1	"	6 "	28	2/17	"	......	"	......
246 - 252..	7	2	2/17	1 adult	7	2/25	"	......	"	......
254	1	0	2/19	30+ nymphs	(n)	3/14	"	......	....	......
275	1	0	2/8	30+ "	25	3/15	"	......	....	......
276 - 279..	4	2	2/24	1 adult..............	19	3/17	"	......	None	......
280	1	1	"	2 adults....	19	3/17	"	......	"	......
316	1	0	3/14	100+ nymphs	(n)	***	"	...	....	......
325	1	0	3/17	100+ "	(n)	***	"	......	....	......
326 - 329..	3	1**	"	10 nymphs......	(n)	4/29	"	......	None	......
330	1	0	"	1 adult...........	16	4/10	"	......	....	......
331 - 336..	6	1	"	1 nymph..................	16	4/10	"	...	None	......
376 - 378..	3	0	3/31	2 adults	29	5/2	One	5/27	....	......
383	1	0	4/10	6 nymphs	17	4/29	None	......	....	......
384	1	0	"	6 adults..................	17	4/29	"	......	....	......
385 - 387..	3	0	"	5 "	17	4/29	"	......	....	......
406	1	0	4/25	8 "	.....	(D'cd)	....	......	....	......
583 - 586..	4	4	9/30	12+ nymphs.......	15	10/15	None	......	None	......
554 - 555..	2	2	10/10	24+ "	20	10/30	"	......	"	......
556 - 562..	7	7*	10/11	12+ "	6+	10/17	"	......	"	......
586 - 591..	6	6**	10/22	40+ "	5+	10/27	"	......	"	......
600	1	1**	10/23	Many nymphs and adults	20+	11/12	"	......	"	......
608 - 618..	11	11*	10/30	24+ nymphs......!.......	18+	11/12	"	......	"	......
625 - 633..	9	9*	11/12	30+ "	12+	11/24	"	......	"	......
506 - 508 / 510 - 512..	4	0	3/12	Many nymphs and adults	(n)	***	None	......	....	......
Total..	87	51	......	....	......	....	One	......	None	......

* Control plants of style *b* used.

** Control plants of style *c* used.

*** These plants were in an outdoor cage.

(n) Insects were not later removed from test plants, so exact length of exposure is not known.

THE MEALYBUGS (*Pseudococcus calceolariae* Mask. and *Ps. sacchari* Ckll.).

Because of the very close relationship and resemblance of these two species—it being impossible to separate them without microscopic examination—and because their habits are so nearly identical, no attempt was made to distinguish or separate them for experimental purposes.

Tests made with mealybugs were all by use of the last two methods, C and D. A total of 40 tests was made, of which number one test plant (No. 577) became infected with mottling disease, apparently as result of transmission by the mealybug.

This was one of a series of seven plants, each subjected, on October 21st, to the attack of 6 adult female mealybugs from mottled cane. For each plant of the series there was grown a control, kept under exactly similar conditions to the test, and having introduced upon it approximately the same number of insects as the test, but insects taken from healthy instead of mottled cane. The plant that became infected first showed indications of disease on November 23rd, a month and two days after introduction of the insects onto plant. The note of this date reads: "Plant shows evidence of mottling near the bases of two uppermost leaves." Note of December 2nd reads: "Plant is becoming quite decidedly mottled, though check plant, No. 577 *a*, shows no sign of disease."

The notes on this plant further show, however, that the check plant also became mottled, the first symptoms becoming manifest on January 26th, over three months after the mealybugs were introduced with plant. There is little doubt that the inoculation of the check plant can be justly considered to have resulted from secondary infection from the test plant, No. 577, in the interim since they were transplanted, side by side and without cover, into field on October 30th.

TABLE VI.

EXPERIMENTS WITH *PSEUDOCOCCUS CALCEOLARIAE* AND *PS. SACCHARI.*(1)

Plant numbers	Number of test plants	Number of controls	Date of confining insects	Insects confined per plant	Days insects confined	Date plant put into field	Test plants became mottled	Date mottling appeared	Controls became mottled	Date mottling appeared on controls
281 to 328..	8	2	2/7	1 Adult	11+	2/18	None...	......	None...	
321 to 324..	4	2	3/15	1 "	*	4/28	" ...	......	" ...	
473 to 476..	4	1	5/30	15 Adults.....	74+	8/12	" ...	......	" ...	
502.........	1	0	8/5	15 Nymphs ..	65+	10/9	" ...	......	....	
516 to 520..	5	1	9/29	10 " ...	18+	10/17	" ...	......	None...	
521 to 522..	2	1	9/29	2 Egg batches........	18+	10/17	None...	......	None...	
573 to 579..	7	7**	10/21	6 Adults. ..	94	10/30	One.....	11/23	One.....	1/26***
580 to 585..	6	6**	10/22	21 Adults and Nymphs ...	81	10/30	None...	......	None...	
595.........	1	1	10/23	7 Nymphs...	*	....	" ...	.....	" ...	
596 to 597..	2	2	10/23	15 " ..	*	....	" ...	.....	" ...	
Total....	40	23	....	....	......	....	One.	......	One***	

(1) It has been impracticable to attempt separation of these two species.

* Insects were not later removed from plant, so exact length of exposure is not known.

** Control plants of style *c* used.

*** As over three months elapsed from the time that insects from healthy plants were introduced onto this control (No. 577 a) before it showed mottling, and as it was contiguous and within ten inches of test plant No. 577 that became mottled, the control is considered to have become diseased as result of secondary infection.

THE YELLOW SUGAR-CANE APHIS (*Sipha flava* Forbes).

It is a matter of regret that a larger number of tests was not conducted with this species, which shows some promise of being one of the principal vectors of the disease. One reason for this statement is the fact that cane plants that are subjected when quite young to the attack of large numbers of the yellow aphis transferred from mottled cane, very early show a kind of very characteristic, long, yellow striping on the leaves, which does not appear on the check plants. This is not considered to be a direct result of the punctures of the aphis, as that manifests itself in another manner, namely, in a dull scarlet stain appearing first near the tips of leaves, where the aphids are most numerous, and extending gradually toward base of leaf. The yellow striping appears along the full length of leaf, not only on the leaves attacked by aphis but on others as well. Unfortunately, many of the plants which displayed the yellow striping most strongly died when they were transferred to field, appearing as if weakened by the condition. A few others recovered entirely from the striped condition. So there is not yet sufficient proof to establish a definite connection between this yellow striping and the

mottling disease, but it is the intention to make further experiments to ascertain if there be a connection.

Only 21 experimental tests were made with the yellow aphis, all of them being by the last two methods, C and D. Of this number, one plant gave evidence of successful transmission of the disease by means of the insect. This plant (No. 531) was one of a series of twelve plants, all similarly subjected to the attack of yellow aphids from mottled cane on September 29th. The first evidence of infection was on October 9th, the note for which date reads: "This plant shows every evidence of being in the first stages of the mottling disease" A later note, of October 30, reads: "Shows advanced stage of attack by mottling disease so far as foliage striping is concerned."

It will be noted that the incubation period of the disease was in this case very short—only 10 days—where in other cases of experimental inoculation by means of insects it has been usually about one month. No explanation has been found for this difference. (See Table VII, page 108.)

THE SUGAR-CANE LEAF SCALE (*Pulvinaria iceryi* Guer.)

This long, pink and green scale, which infests only the leaves, is a species so rare in the cane fields of the Island that there seems small likelihood of its ever becoming an important agent in the transmission of the cane mottling disease So far as we know it has been observed and collected only by the writer, who found it first on sugar cane in an outdoor breeding cage at Santa Rita, on the south coast, on October 3, 1914, and again on December 26, 1914, in the same rearing cage, on which occasion it was recorded as highly parisitized by two small wasps, a black one and a still smaller yellow one.

The scale was not again observed until the spring of 1918, when the writer found it heavily infesting a cane plant in the experimental greenhouse of the station at Río Piedras; and on this occasion also it was heavily parasitized by the two species of Chalcidids. These facts would lead to a belief that both the scale and its two parasites are endemic to the Island, though not yet observed in cane fields.

In the late summer of 1918 specimens of this scale were sent at my request by Mr. M. A. Crespo, then assistant entomologist of the station, to Dr. L. O. Howard, entomologist of the U. S. Department of Agriculture, and the species was determined by Mr. H. Morrison, of the federal department, as *Pulvinaria iceryi* (Guer.), a species previously recorded only from Mauritius and Reunión. If it proves

true that this scale is identical with the "poche blanche" of Mauritius, but is indigenous to Porto Rico, it may turn out to have been introduced into Mauritius from this Island, and will constitute a very parallel case to that of the introduction of *Phytalus smithi* Arrow from Barbados into Mauritius—a case in which a species held in natural check in its native environment, greatly multiplies and becomes a serious pest in the new environment, where it is freed from its parasites.

For the past year this scale has been reared generation after generation on cane in confinement, but when infested canes are transplanted to the outdoors the scales soon disappear from the plants.

Only 14 experimental tests were made of the possible transmission of cane mottling disease by this scale, and of this number, one successful inoculation resulted. This plant (No. 426) was one of a series of four test plants, each subjected on April 28th to the attack of from 5 to 10 adult scales transferred from mottled cane. First evidence of the disease appeared on May 31st, on which date the following note was made: "Plant shows none of the mottling due directly to scale attack, as in 423 and 425, but the terminal 2 leaves show strongly a mottling very similar to mosaic disease." A later note, of July 22nd, reads: "Plant is most decidedly mottled now, and quite heavily infested with the scale."

As to the direct injury to young cane plants from attack of the scale, mentioned above, a note concerning another test plant of the same series (No. 423), under date of May 31st, may be quoted: "Some lower leaves show a peculiar yellow mottling, more profuse and quite unlike the mosaic disease (which appears in terminal leaves first). This is especially true of leaves most heavily infested with scale." This mottling effect on the foliage was of a rather different nature than the yellow striping caused on young plants by aphis attack, but like it, seemed to disappear as a plant increased in growth, so its connection with the mottling disease is doubtful. (See Table VII, page 108.)

THE YELLOW SUGAR-CANE THRIPS (*Frankliniella* sp.).

This thrips appears to be an undescribed species of the genus, and will be described by the writer in an early number of this journal. The pest and its damage have been fully discussed in a previous paragraph.

Seventeen test plants were subjected to the attack of this thrips, but no succesful inoculations resulted. This may have been due,

however, to the fact that the living specimens which were introduced into cages with young plants had been brought across the Island from the south coast, and were one to two days on the journey and weakened to a certain extent, many of them having died *en route*. The species has not been found in sufficient numbers on cane at Río Piedras to make experimental tests. It is the intention to make further tests with this insect in the coming year. (See Table VII.)

THE BLACK SUGAR-CANE THRIPS (*Haplothrips tibialis* Hood?).

This insect has been doubtfully refered to the above species of Hood on the strength of that species having been described from a thrips collected on sugar-cane at Río Piedras; but the description is not at present available. In Moulton's key the insect runs to the genus Anaphothrips

In habits this species differs from the yellow cane thrips in that both nymphs and adults live near the extremeties of the leaves, never at the bases. The species may be found on young cane only, and seldom becomes abundant. Usually only isolated individuals are found. Specimens were first noticed on grass blades on March 13th, both adults and nymphs, but when transferred to a young cane they continued to thrive, and by April 25th had become so numerous on the cane plant as to cause its death. The leaves were entirely speckled with brown from the attack. From April through June succeeding generations were reared on cane. Under outdoor conditions, the insect is probably more common on grasses.

Only four tests were made with this insect, in attempt to transfer the mottling disease, all of which were negative. (See Table VII.)

THE FALSE-MOTTLING LEAFHOPPER (not determined).

Like some other cane pests, this leafhopper lives more commonly on grasses, and seems to attack only very young canes. In the field it has been rarely observed, probably because of its small size, inconspicuous coloring, and its agility. The nymphs are very pale, almost white in color, and live near the tips of the leaves on sugar-cane, though on grasses they may occur anywhere on the undersides of leaves.

In common with the black thrips, this insect made its appearance on young cane plants during February, and in March became very common, but by April adults were again scarce. A second generation appeared in May and June, and what is believed to be a third generation in August. Cane leaves showing attack become streaked

with long white marks, from the extraction of the chlorophyll, in a manner very suggestive of the mottling disease. From this the insect receives its common name, false-mottling leafhopper.

Only five tests, of their ability to transmit mottling diseases, were made with this leafhopper, all of which gave negative results. (See Table VII.)

THE CANE SEED-HEAD LEAFHOPPER (*Balclutha* sp.).

This is a small leafhopper of the general shape of *Kolla similis* Walk., but only two-thirds its size and varying from pale green to yellowish-brown in color. In December and January it occurred in the greatest abundance in the seed tassels of such cane plants as bore seed, and is believed to have been a principal cause of the low fertility of the seed. For this reason it may be a serious retarding factor in production of new cane varieties. The nymphs, which are dark in color with lighter dorsal stripe, could be shaken by thousands from a single cane seed tassel. They were heavily preyed upon by larvae of a Syrphid fly.

Through the summer, when no cane is seeding, this leafhopper thrives in great abundance on the seed-heads of common pasture grass, or "malojillo" (*Eriochloa subglabra*), where it is heavily parasitized by a black, ant-like Dryinid wasp (*Chalcogonatopus* sp.), and by a fungus that seems to follow attack of the parasite larva.

These leafhoppers come in abundance to electric light, and might be controlled by means of trap lights. As they do not appear to attack sugar cane except rarely when it is not in seed, it is unlikely that they can be a factor in transmission of the mottling disease Five tests were made with the species (two of them by method B), all giving negative results. (See Table VII.)

THE SUGAR-CANE RED-SPIDER (*Oligonychus viridis?*)

This very small mite is barely visible to the naked eye because of its size and protective coloration. It lives and reproduces on the cane foliage, usually on underside along the midrib, sometimes spinning a fine web over the infested portions of leaf, and by sucking the chlorophyll from the leaf it causes a white blotching or streaking that might be mistaken for mottling by one unfamiliar with the disease. The adult insect has eight legs and is a very small spider, pale greenish or yellowish in color with dark markings at the sides. It differs only in feeding habits and microscopic details from some

other common species of red-spider, and is a species capable of rapid multiplication.

Because of its minute size, this mite has been difficult to keep out of experimental cages containing other insects; and if it be proved to transmit the disease, it can have been responsible for apparent transmissions by other insects, since any portion of leaf bearing insects that is dropped into a cage to infest a plant, or plants, will unavoidably harbor young or eggs of red-spider. The six tests made using red-spider alone gave negative results. (See Table VII.)

TABLE VII.

EXPERIMENTS WITH *SIPHA FLAVA* FORBES.

Plant Numbers	Plants Subjected to Insects	Control Plants	Date of Confining Insects	Insects Confined per Plant	Days Insects were confined	Date Plant put into Field	Test Plants Became Mottled	Number of Mottled Test Plant	Date Mottling Appeared	Controls Became Mottled	Number of Control	Date Control Became Mottled
853	1	0	3-19	1 adult	....	(Died)	.....	.....	.....	.....	.....	......
412-417.	6	1	4-26	20+ adults and young	31(c)	8-11	None	.....	.....	None	...	....
418 119	2	1	4-26	12+ " " "	34(c)	8-11	"	.. .	.. ..	"	....	......
523-582.	12	3(a)	9-29	100+ " " "	16(c)	10-15	One	531	10-9	One	531	1-26
Total	21	5	Plants became diseased				One test plant			One control (d)		

EXPERIMENTS WITH *PULVINARIA ICERYI* (GUER.).

423-426.	4	0	4-28	5-10 scales	(c)	8-11	One	426	5-31	....	....	......
550-552.	3	3(a)	10-10	10+ "	(c)	10-17	None	.. .	....	None	.....	......
593-594.	2	2(b)	10-23	12+ "	(c)	11-12	"	...	.. .	"	.....	.....
603 607.	3	3(b)	10-30	10+ "	(c)	11-12	"	.....	....	"	.....	.....
660-661.	2	2( )	11-30	15+ "	(c)	2-16	"	. ..	.....	"	.....	......
Total	11	10	Plants became diseased				One test plant			No control		

EXPERIMENTS WITH THE YELLOW CANE THRIPS.

168-174.	12	2	1-10	8+ adults	24+	2-8	None	......	....	None	.....	......
178-182.	5	1	1-10	8+ "	36+	2-15	"	......	......	"	......	......
Total	17	3	Plants became diseased				No test plant			No control		

EXPERIMENTS WITH THE BLACK CANE THRIPS.

467	1	0	5-28	18 adults..............	(c)	8-12	None	......	......	......	......	......
484-486.	3	1	5-30	15+ adults.............	(c)	8-18	"	......	......	None	......	......
Total	4	1	Plants became diseased				No test plant			No control		

TABLE VII—Continued.

EXPERIMENTS WITH THE FALSE-MOTTLING LEAFHOPPER.

Plant Numbers	Plants Subjected to Insects	Control Plants	Date of Confining Insects	Insects Confined per Plant	Days Insects were Confined	Date Plant put into Field	Plants Became Mottled	Number of Mottled Plant	Date Mottling Appeared	Controls Became Mottled	Number of Controls	Date Control Became Mottled
348.....	1	1	3-17	8 adults	(c)	6-2	None	......	......	None	......	......
360.....	1	1	3-31	4 nymphs	24	6-2	"	......	......	"	......	......
374.....	1	1	3-31	2 adults	30	6-2	"	......	......	"	......	......
464.....	1	1	5-27	1 nymph...............	(c)	8-12	"	......	......	"	......	......
487.....	1	1	6-2	2 adults and 1 nymph..	(c)	8-13	"	..		"	......	......
Total	5	5		Plants became diseased			No test plants			No controls		

EXPERIMENTS WITH THE CANE SEED-HEAD LEAFHOPPER.

278.....	1(e)	1	2-19	100 adults	(c)	...	None	.....	.....	None	......	......
282.....	1(e)	0	2-19	100 adults	(c)	....	"	.....	....	.....	......	......
313.....	1	1	3-14	1 adult......	(c)	6-2	"	.....	.....	None	...	......
405.....	1	1	4-25	1 adult........... ..	(c)	8-12	"	.....	....	"	....	......
Total	4	3		Plants became diseased			No test plants			No checks		

EXPERIMENTS WITH THE SUGAR-CANE RED-SPIDER.

447-452.	6	2	4-30	All stages (f).	(c)	8-5	None	.....	......	None	.....	......

(a) Control plants of style *b* used.
(b) Control plants of style *c* used.
(c) Insects not removed from cane plant before it was transplanted to field.
(d) This control plant undoubtedly became diseased by inadvertent secondary infection.
(e) Mottled and healthy plant in same cage, method A.
(f) A portion of mottled cane leaf containing all stages of the red-spider dropped into cage with plant.

EXPERIMENTS WITH CHEWING INSECTS.

As explained in a previous paragraph, the possibility of mottling disease being transmitted by any species of chewing insect seems so remote that very little experimntal effort has been expended along this line of investigation.

The insect that has received most attention is the cone-headed katydid (*Neoconocephalus mexicanus* Sauss.). Seven test plants were employed, one with adults and six by using nymphs. The latter were transferred successively from mottled to healthy plants several times, in close succession, but the healthy plants eaten as result of these transfers gave no later indications of mottling. (See Table VII.)

With the common field grasshopper (*Schistocerca columbina*

Thunb.) and the dusky ground grasshopper (*Sphingonotus haitensis* Sauss.) two tests each were made, all proving negative.

A test each was made with the changa (*Scapteriscus vicinus* Scud.), the spider-legged cricket (*Amphiacustes annulipes* Sauss.) and a common roach (undetermined), in each case the insects being introduced into a small cage with young healthy cane after confinement for a week or more with mottled cane. All gave negative results. (See Table VII.)

A test each was made with the two common May-beetles of the north coast (*Phyllophaga portoricensis* Smyth and *P. citri* Smyth), adults in each case being introduced in numbers into a cage containing young mottled and healthy cane plants mixed. No healthy plants became mottled as result, within a space of six months, when plants were uprooted.

A test each was made with the three following arthropods, using the same method as that used with the crickets and roaches: sowbugs (*Porcellio* sp.), the flat greenhouse milliped (*Parajulus* sp.), and young of the common bush milliped (*Rhinocricus arboreus* Sauss.). All gave negative results.

TABLE VIII.

EXPERIMENTS WITH CHEWING INSECTS.

Species of insects	Plants subjected to attack	Control plants	Date of confinement	Insects per plant	Days confined	Results
Neoconocephalus mexicanus	1	1	Jan. 10	1 adult	16	Negative
" "	1	0	" 10	1 nymph	10	"
" "	1	1	Feb. 17	10 nymphs	4	"
" "	1	1	" 21	1 nymph	17	"
" "	1	0	" 21	1 "	17	"
" "	1	1	Mar. 14	1 "	17	"
" "	1	0	" 14	1 "	17	"
Schistocerca columbina	1	1	Jan 10	1 adult	20	"
" "	1	1	Oct. 23	2 nymphs	7	"
Sphingonotus haitensis	1	1	Jan. 10	1 adult	4	"
" "	1	0	" 10	1 "	10	"
Amphiacustes annulipes	1	1	Oct. 10	8 nymphs	7	"
Scapteriscus vicinus	1	1	" 23	1 adult	**	"
Roach (*Blatta* sp.)	1	1	" 24	8 nymphs	19	"
Sow-bug (*Porcellio* sp.)	1	1	" 24	11 adults	19	"
Milliped (*Parajulus* sp.)	1	1	" 10	6 "	7	"
Milliped (*Rhinocricus arboreus*)	1	1	" 28	15 young	**	"
Phyllophaga portoricensis	2*	0	May 29	10 adults	**	"
Phyllophaga citri	2*	0	" 29	10 "	**	"
Total number of plants	21	13	All results negative			

* The May-beetles were introduced into outdoor cages containing both mottled and healthy cane, according to method A.

** Insects were not removed from these plants up to the time plants were transplanted to the field.

SUMMARY.

1. Failure of other and ordinary means of dispersion of plant diseases to account for the rapid spread of the cane mottling disease, under normal conditions, has led to a belief that the disease may be carried by insects.

2. Until substantial proof has been given that the cane mottling disease results from an organism capable of bearing fructifications or forming spores, there seems better reason to suspect sucking than chewing insects of transmitting the disease.

3. Field observations have thrown little light on the problem of insect transmission of mottling disease, the only insect yet observed which might satisfy all conditions, on the South Coast at least, being the yellow cane thrips (*Frankliniella* sp.).

4. It is believed that secondary infection with mottling disease, in a field planted to healthy seed, might occur from slow-moving insects like the mealybug or rust-mite, that could harbor over in numbers on stubble, volunteer cane or grass from a previous infected crop. This renders important the clean cultivation of cane fields between crops. These pests cannot, however, account for wide and rapid spread of mottling disease among plants grown from healthy seed and planted in new ground.

5. From the large number of experimental tests made in insect transmission, only four successful inoculations resulted. These four were all from different species of insects; but it is unique that all resulted from sucking insects. One of these was the West Indian cane-fly, a second the cane leaf scale, a third the yellow cane aphis, and a fourth the mealybug. (See foot note on page 83.)

6. No successful inoculations of mottling disease resulted from experimental tests with chewing insects. The number of such tests made was, however, not large.

7. In view of the small number of successful inoculations secured, as compared with the rather large number of tests made, under conditions which were considered favorable, the question of insect transmission of cane mottling disease cannot be looked upon as settled. Factors not visible to the investigator may have entered into the success of the inoculations, other than the factor of insect attack.

8. Future attempts will be made to duplicate inoculations which have thus far been secured from apparent insect transmission. It is significant, however, that in our experiments as thus far made

no control plants have become diseased (except by what was very evidently later secondary infection).

9. It is not improbable that, in common with certain other similar diseases of plants, inoculation of a healthy cane plant with mottling disease requires that the plant be in a condition of rapid growth. As our potted cane test-plants were not always in a condition of rapid growth at time that insects were introduced with plants, this may have acted as an inhibitive factor in the success of the inoculations.

10. The question of the infective principle of the disease being carried by the insect for some length of time, and undergoing a cyclic change within the insect body, or of its being transmitted to the young through the egg, before it becomes pathogenic to the plant host through the medium of the insect's bite, is yet to be investigated.

A BIBLIOGRAPHY OF INSECT-BORNE DISEASES OF PLANTS.[1]

1. HAWAIIN CANE ROOT DISEASE, *Ithyphallus coralloides.*

(1) 1906. COBB, N. A. Fungus maladies of the sugar cane. Bul. 5, Hawaiian S. P. A. Exp. Sta. (E. S R. 18, 843.)

(2) 1909. COBB, N. A. Fungus maladies of the sugar cane. Bul. 6, Hawaiian S. P. A. Exp. Sta. (E. S. R. 22, 49.)

2. WHITE PINE BLISTER RUST, *Cronartium ribicola*

(3) 1917. GRAVATT, G. F., and MARSHALL, R. P. Arthropods and gastropods as carriers of *Cronartium ribicola* in greenhouses. Phytopath. VII, 5, 368–373. (E. S. R. 39, 248.) (R. A. E. 6, 9.)

(4) 1918. GRAVATT, G. F., and POSEY, G. P. Gypsy-moth larvæ as agents in dissemination of the white pine blister rust. Jl. Agr. Res. XII, 7, 459–462. (E. S. R. 38, 860.) (R. A. E. 6, 225.)

(5) 1919. SNELL, WALTER H. Observations on the relation of insects to the dissemination of *Cronartium ribicola.* Phytopath. IX, 10, 451–464.

3. CHESTNUT BLIGHT, *Endothia parasitica.*

(6) 1914. STUDHALTER, R. A. Insects as carriers of the chestnut blight fungus. Phytopath. IV, 1, 52. (E. S. R. 31, 451,)

[1] This list has been prepared to include only the more important recent writings on insect transmission of diseases occurring in America The diseases are numbered in accordance with the numbers given them in Tables I and II, pages 86 to 89.

(7) 1915. STUDHALTER, R. A., and RUGGLES, A. C. Insects as carriers of the chestnut blight fungus. Bul. 12, Penn. Dept. Forestry. (E. S. R. 34, 448 and 34, 853.)

4. CURRANT BLIGHT, *Botryosphæria ribis.*

(8) 1911. GROSSENBACHER, J. G. and DUGGAR, B. M. A contribution to the life-history, parasitism and biology of *Botryosphæria ribis.* Tech. Bul. 18, N. Y. Agr. Exp. Sta., Geneva. (E. S. R. 25, 848.)

5. TREE-CRICKET CANKER, *Leptosphæria coniotherium.*

(9) 1907. CLINTON, G. P. Notes on fungus diseases for 1906. Conn. Exp. Sta. Rept. for 1906. (E. S. R. 18, 1138.)

(10) 1914. PARROTT, P. J., and FULTON, B. B. Tree crickets injurious to orchard and garden fruits. Bul. 388, N. Y. Exp. Sta., Geneva. (E. S. R. 31, 649.) (R. A. E. 2, 673.)

(11) 1915. PARROTT, P. J., GLOYER, W. O., and FULTON, B. B. Some studies on the snowy tree-cricket with reference to an apple bark disease. Jl. Econ. Ent. VIII, 6, 535–541. (E. S. R. 34, 653.) (R. A. E. 4, 71.)

(12) 1916. GLOYER, W. O., and FULTON, B. B. Tree crickets as carriers of *Leptosphæria coniotherium* and other fungi. Tech. Bul. 50, N. Y. Exp. Sta., Geneva. (E. S. R. 35, 547.) (R. A. E. 4, 342.)

6. APPLE BITTER-ROT, *Glomerella cingulata.*

(13) 1902. CLINTON, G. P. Apple rots in Illinois. Bul. 69, Ill. Exp. Sta. (E. S. R. 13, 1059.)

(14) 1907. BURRILL, T. J. Bitter rot of apples. Bul. 118, Ill. Exp. Sta. (E. S. R. 19, 656.)

(15) 1918. ROBERTS, J. W. The sources of apple bitter rot infection. Bul. 684, U. S. D. A. (E. S. R. 39, 551.)

7. TOMATO LEAF-SPOT, *Septoria lycopersici.*

16) 1918. MARTIN, W. H. Dissemination of *Septoria lycopersici* by insects and pickers. Phytopath. VIII, 7, 365–372. (E. S. R. 40, 644.)

8. CARNATION BUD-ROT, *Sporotrichum poæ.*

(17) 1908. HEALD, F. D. The bud rot of carnations. Bul. 103, Neb. Exp. Sta. (E. S. R. 19, 855.)

(18) 1908. STEWART, F. C., and HODGKISS, H. E. The *Sporotrichum* bud rot of carnations and the silver top of June grass. Tech. Bul. 7, N. Y. Exp. Sta., Geneva. (E. S. R. 20, 647.)

9. INTERNAL DISEASE OF COTTON BOLLS.

(19) 1916. ——— ———. Cotton Conference. Pests and diseases of cotton, and their control. Agricultural News, Barbados, XV, 368, 182–183, June 3, 1916.

(20) 1917. NOWELL, WM. Internal disease of cotton bolls in the West Indies. W. I. Bulletin, XVI, 3, 203–235. (E. S. R. 39, 754.) (R. A. E. 5, 580.)

(21) 1918. NOWELL, WM. Internal disease of cotton bolls in the West Indies, II. W. I. Bulletin, XVII, 1, 1–26. (E. S. R. 41, 251.) (R. A. E. 6, 454.)

10. FIRE BLIGHT, *Bacillus amylovorus.*

(22) 1891. WAITE, M. B. Results from recent investigations in pear blight. Bot. Gaz. 16, 259.

(23) 1911. JONES, DAN H. *Scolytus rugulosus* as an agent in the spread of bacterial blight in pear trees. Phytopath. I, 5, 155–158. (E. S. R. 26, 144.)

(24) 1913. STEWART, V. B. The importance of the tarnished plant bug in the dissemination of fire blight in nursery stock. Phytopath. III, 6, 273–276. (E. S. R. 30, 650.) (R. A. E. 2, 288.)

(25) 1914. JONES, B. J. The natural modes of distribution of fire blight. Mo. Bul. Cal. Comm. Hort. III, 12, 505–511. (R. A. E. 3, 149.)

(26) 1915. BURRILL, A. C. Insect control important in checking fire blight. Phytopath. V, 6, 343–347. (E. S. R. 34, 648.)

(27) 1915. BURRILL, A. C. Sedentary aphids *vs.* Spread of fire Blight. Jl. Econ. Ent. VIII, 6, 552–553. (Note.)

(28) 1916. STEWART, V. B., and LEONARD, M. D. Further studies in the role of insects in the dissemination of fire blight bacteria. Phytopath. VI, 2, 152–158. (E. S. R. 36, 351.) (R. A. E. 5, 79.)

(29) 1918. LATHROP, FRANK H. Leaf-hoppers injurious to apple trees. Bul. 451, N. Y. Exp. Sta., Geneva. (E. S. R. 41 252.) (R. A. E. 6, 207.)

11. BACTERIAL WILT OF CUCURBITS, *Bacillus tracheiphilus.*

(30) 1915. RAND, F. V. Dissemination of bacterial wilt of cucurbits. Jl. Agr. Res. V, 6, 257–260. (E. S. R. 34, 244.) (R. A. E. 4, 38.)

(31) 1916. RAND, F. V., and ENLOWS, ELLA M. A. Transmission and control of bacterial wilt of cucurbits. Jl. Agr. Res. VI, 11, 417–434. (E. S. R. 35, 546.) (R. A. E. 4, 385.)

12. SUGAR BEET CURLY-TOP.

(32) 1909. BALL, E. D. The leafhoppers of the sugar beet and their relation to the "curly-leaf" condition. Bul. 66, Pt. IV, Bu. Ent., U. S. D. A. (E. S. R. 20, 954.)

(33) 1910. SHAW, H. B. The curly-top of beets. Bul. 181, Bu. Plant Indus., U. S. D. A. (Science, May 13, 1910.) (E. S. R. 23, 450.)

(34) 1915. SMITH, R. E., and BONCQUET, P. A. New light on curly-top of the sugar beet. Phytopath. V, 2, 103–107. (E. S. R. 33, 743.)

(35) 1915. BONCQUET, P. A., and HARTUNG, W. J. The comparative effect upon sugar beets of *Eutettix tenella* Baker from wild plants and from curly-leaf beets. Phytopath. V, 6, 348–349. (E. S. R. 34, 646.)

(36) 1917. BALL, E. D. The beet leafhopper and the curly-leaf disease that it transmits. Bul. 155, Utah Exp. Sta. (E. S. R. 38, 360.) (R. A. E. 5, 213.)

(37) 1917. BONCQUET, P. A., and STAHL, C. F. Wild vegetation as a source of curly-top infection of sugar beets. Jl. Econ. Ent. X, 4, 392–397. (E. S. R. 37, 847.) (R. A. E. 5, 492.)

(38) 1918. STAHL, C. F., and CARSNER, EUBANKS. Obtaining beet leafhoppers nonvirulent as to curly-top. Jl. Agr. Res. XIV, 9, 393–394. (E. S. R. 39, 763.) (R. A. E. 6, 564.)

(39) 1919. CARSNER, EUBANKS. Susceptibility of various plants to curly-top of sugar beet. Phytopath. IX, 9, 413–421.

(40) 1919. SEVERIN, H. H. P. The beet leafhopper: A report on investigations into its occurrence in California. Facts About Sugar, VIII, 7 (p. 130), 8 (150), 9 (170), 10 (190), 11 (210), 12 (230) and 13 (250). (E. S. R. 41, 456.)

13. SPINACH BLIGHT.

(41) 1918. MCCLINTOCK, J. A., and SMITH, LORAN B. The true nature of spinach blight and the relation of insects to its transmission. Jl. Agr. Res. XIV, 1, 1–60. (E. S. R. 39, 550.) (R. A. E. 6, 453.)

14. TOBACCO MOSAIC DISEASE.

(42) 1914. ALLARD, H. A. The mosaic disease of tobacco. Bul. 40, U. S. D. A. (E. S. R. 30, 450.)

(43) 1915. CLINTON, G. P. Chlorosis of plants, with special reference to calico of tobacco. Rept. of Botanist (Ann. Rpt. 1914, Pt. VI), Conn. Exp. Sta. (E. S. R. 34, 52.)

(44) 1916. ALLARD, H. A. Some properties of the virus of the mosaic disease of tobacco. Jl. Agr. Res. VI, 17, 649–674. (E. S. R. 35, 751.)

(45) 1916. ALLARD, H. A. A specific mosaic disease of *Nicotiana viscosum* distinct from the mosaic disease of tobacco. Jl. Agr. Res. VII, 11, 481–486. (E. S. R. 36, 451.)

(46) 1917. ALLARD, H. A. Further studies of the mosaic disease of tobacco. Jl. Agr. Res. X, 12, 615–632. (E. S. R. 38, 49.) (R. A. E. 5, 577.)

(47) 1918. ALLARD, H. A. The mosaic disease of *Phytolacca decandra*. Phytopath. VIII, 2, 51–54. (E. S. R. 39, 549.)

15. POTATO MOSAIC DISEASE.

(48) 1919. SCHULTZ, E. S., FOLSOM, D., HILDEBRANDT, F. M., and HAWKINS, L. A. Investigations on the mosaic disease of the Irish potato. Jl. Agr. Res. XVII, 6, 247–274. (E. S. R. 42, 47.)

16. CUCUMBER MOSAIC DISEASE.

(49) 1916. DOOLITTLE, S. P. A new infectious mosaic disease of cucumber. Phytopath. VI, 2, 145–147. (E. S. R. 36, 349.)

17. POTATO HOPPERBURN.

(50) 1919. BALL, E. D. The potato leafhopper and its relation to the hopperburn. Jl. Econ. Ent. XII, 2, 149–154. (E. S. R. 41, 849.)

(51) 1919. BALL, E. D. The potato leafhopper and the hopper burn that it causes. Bul. 23, Wis. Dept. Agr., pp. 76–102. (E. S. R. 41, 848.)

18. SUGAR CANE MOTTLING DISEASE.

(52) 1919. BRANDES, E. W. The mosaic disease of sugar cane and other grasses. Bul. 829, U. S. D. A.

(53) 1919. SMYTH, E. G.* Entomological work (the yellow-stripe disease of sugar-cane). Rept. of Comm. of Agr. and Labor of P. R. (from Rept. of the Governor of Porto Rico, 1919, pp. 685–713), Bureau of Insular Affairs, War Dept., Washington, page 699.

* See foot note on page 134.

AN ANNOTATED BIBLIOGRAPHY OF PORTO RICAN CANE INSECTS.*

By E. GRAYWOOD SMYTH.

(1) 1880. STAHL, A.
La Enfermedad de la Caña de Azúcar en Puerto Rico, 1880.

(2) 1882. STAHL, A.
Fauna de Puerto Rico. Clasificación sistemática de los Animales que Corresponden a Esta Fauna y Catálogo del Gabinete Zoológico del Doctor A. Stahl en Bayamón, Puerto Rico. Imprenta del "Boletín Mercantil," 37 Calle de la Fortaleza, San Juan, 1882, pp. 249.
Insectos, pp. 169–213. Lists *Sphenophorus sericeus* Latr. (=*Metamasius hemipterus* Linn.), *Laphygma frugiperda* S. & A., and *Gryllotalpa hexadactyla* (=*Scapteriscus vicinus* Scud.).

(3) 1884. UMPIERRE, MANUEL FERNÁNDEZ.
Distintas Causas que Perjudican a la Caña Durante su Existencia, pp. 70–76. *In* Manual Práctico de la Agricultura de la Caña de Azúcar, Puerto Rico. Imprenta del Boletín Mercantil, calle de la Fortaleza, Núm. 37, San Juan, 1884, pp. 199.
Mentions grass-worms, moth stalk-borer and mealybug.

(4) 1886. BALY, J. S.
Descriptions of Uncharactèrized Species of Diabrotica. *In* Trans. Ent. Soc., London, 1886. Part IV (December, 1886), pp. 443–445.
From P. R., *Diabrotica graminea* sp. n., p. 443.

(5) 1886. QUEDENFELDT, E.
Neuse und seltnere Kafer von Portorico. *In* Berliner Entomolog. Zeitschrift, pp. 119–128.

(6) 1887. GUNDLACH, JUAN.
Fauna Puerto-Riqueña. Anales de la Sociedad Española de Historia Natural, Tomo XVI, Cuad. 1, Madrid, Alcalá 11, 31 de mayo de 1887.
Insectos, pp. 347–658.

(7) 1889. KRUGER, DR. W.
Das Zuckerrohr und seine Kultur, p. -312.
Records *Delphax saccharivora* Westw.

(8) 1895. TUERO, FERNANDO LÓPEZ.
Enemigos de la Caña y Modo de Combatirlos, Capítulo IV, pp. 63–74. Enfermedad de la Caña de Azúcar, pp. 105–123. *In* La Caña de Azúcar en Puerto Rico, su Cul-

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* References are arranged chronologically, but alphabetically under each year. Anonymous articles are indicated by dashes

tivo y Enfermedad. Tipografía de "Boletín Mercantil," calle de la Fortaleza 24, San Juan, 1895.

Under "Clasificación del Insecto," pp. 114–115, discusses "el caculo" as belonging to genus Leuco thyros and including 5 species, his descriptions of which seem to include Phyllophaga, Dyscinetus and Ligyrus. Figures (Lámina 2) the egg, larva, pupa and adult of *Phyllophaga* sp.

(9) 1900. BUSCK, A.

Notes on a Brief Trip to Puerto Rico in January and February, 1899. *In* U. S. D. A., Bu. Ent., Bul. 22 (n. s.), 1900, pp. 88–92.

Mentions *Diatræa saccharalis, Sphenophorus sexguttatus* Drury, a lemellicorn larva, and *Dactylopius sacchari* as cane pests, and discusses the *changa* as a tobacco pest.

(10) 1900. PERGANDE, T. and COCKERELL, T. D. A.

List of Coccidæ Collected by Mr. A. Busck in Puerto Rico, 1899. *In* U. S. D. A., Bu. Ent., Bul. 22 (n. s.), 1900, pp. 92–93.

Lists *Dactylopius sacchari* Ckll. from three localities on cane.

(11) 1901. GARDNER, F. D.

Ann. Rept., P. R. Agr. Expt. Sta., U S. D. A., for 1901 (Ann. Rept. Office Expt. Stations, Washington, June 30, 1901), pp. 381–415.

Scapteriscus didactylus, p. 414.

(12) 1901. ——— ———.

Notes from Correspondence. *In* U. S. D A., Bu. Ent., Bul. 30 (n. s.), pp. 97–98.

Diaprepes abbreviatus sent in by J. W. Van Leenhoff from Porto Rico.

(13) 1902. BARRETT, O. W.

The Changa or Mole-Cricket (*Scapteriscus didactylus* Latr.) in Porto Rico. Bul. 2, P. R. Agr. Expt. Sta., U. S. D. A., Mayagüez, Sept. 13, 1902, pp. 19, fig. 1.

Dealt with as pest of "tobacco, cane, and small crops."

(14) 1903. FERNALD, MRS. M. E.

Catalogue of the Coccidæ of the World. Bul. 88, Hatch Expt. Sta., Mass. Agr. College, Mar. 1903, pp. 360.

Lists *Pseudococcus sacchari* (Ckll.) on sugar cane from Porto Rico (p. 109).

(15) 1903. GARDNER, F. D.

Annual Rept. of the P. R. Agricultural Experiment Station for 1902. *In* Ann. Rept., Office Exp. Stations for June 30, 1902, Washington, 1903, pp. 331–357.

Discusses may-beetle and larva (p. 343) and gives

extract of Bul. 2 of same station, dealing with changa (pp. 343–352).

(16) 1904. Barrett, O. W.
Control of the Brown Ant (*Solenopsis germinata* Fabr.) in Orange Orchards. Cir. 4, P. R. Agr. Expt. Sta., U. S. D. A., May 9, 1904, pp. 3.
Discussed as a citrus pest. Mentions *Lachnosterna* sp. (p. 3).

(17) 1904. Barrett, O. W.
Report of O. W. Barrett, Entomologist and Botanist. *In* Ann. Rept., P. R. Agr. Exp. Sta. for 1903 (Ann. Rept. Office Exp. Stations, June 30, 1903), Washington, 1904, pp. 429–450.
Discusses white ants (*Eutermes morio?*) (pp. 442–443), *changa* (pp. 443–447), *Exophthalmus spengleri* (p. 446) and the larva of a weevil (apparently *Sphenophorus*) (p. 448).

(18) 1904. Earle, F. S.
Report on Observations in Porto Rico. *In* Ann. Rept., P. R. Agr. Exp. Sta., U. S. D. A., for 1903 (Ann. Rept. Office Exp. Stations, June 30, 1903), Washington, 1904, pp. 454–468.
Note on *Lachnosterna* sp. (p. 459) and a small ant, presumably Solenopsis, injuring orange trees.

(19) 1905. Barrett, O. W.
Report of the Entomologist and Botanist. *In* Ann. Rept., P. R. Agr. Exp. Sta, U. S. D. A. for 1904 (Ann. Rept. Office Expt. Stations, June 30, 1904), Washington, 1905, pp. 387–399.
Discusses *Solenopsis germinata* on citrus (p. 388), also the *changa*, the termite (*Eutermes morio*), the weevil (*Exophthalmus spengleri*) and 4 Lamellicorn beetles (p. 396).

(20) 1905. Kellogg, Vernon L.
American Insects, New York, Henry Holt and Company, 1905, pp. 694, plates.
Scapteriscus didactylus in Porto Rico, p. 161.

(21) 1905. Van Leenhoff, J., Jr.
Tobacco Investigations in Porto Rico during 1903–4. Bul. 5, P. R. Agr. Exp. Sta., U. S. D. A., Mayagüez, 1905, pp. 47.
Note on control of *changa*, p. 13.

(22) 1906. Cook, Melville T.
Informe del Departamento de Patología Vegetal. *In* Primer Informe Anual, Estación Central Agronómica de Cuba, Apr. 1, 1904, to June 30, 1905, Habana, 1906, pp. 147–207.
Note on damage of *changa* in P. R., p. 198.

(23) 1906. EVANS, W. H.
Exhibitions and notes, p. 22. *In* Proc. Hawaiian Ent. Soc., I (1905), Apr. 3, 1906, p. 22.
Mentions the fire flies (Pyrophorus) and *Scapteriscus didactylus* Latr. in Porto Rico.

(24) 1906. HENRICKSEN, H. C.
Report of the Horticulturist. *In* Rept. on Agr. Investigations in P. R., 1905 (Bul. 171, Office Exp. Stations, U. S. D. A., 1906), pp. 23–41.
Notes May-beetle (pp. 24–28), brown ant (p. 28) and *Exophthalmus spengleri* (p. 27) among citrus pests.

(25) 1906. MAY, D. W.
(Report of Special Agent in Charge.) *In* Rept. on Agr. Investigations in P. R., 1905 (Bul. 171, Office Exp. Stations, U. S. D. A., 1906), pp. 1–21.
Mentions *Diatræa saccharalis* Fab. damaging cane.

(26) 1907. TOWER, W. V.
Report of the Entomologist and Plant Pathologist. *In* Ann. Rept., P. R. Agr. Exp. Sta. for 1906, Mayagüez, Apr. 18, 1907, pp. 25–28.
Notes the May-beetle and leaf-weevil, *Diaprepes spengleri* (p. 26), among citrus pests, and *Diatræa saccharalis* (p. 28) as damaging cane.

(27) 1908. MAY, D. W.
Summary of Investigations. *In* Ann. Rept., P. R. Agr. Exp. Sta. for 1907, Mayagüez, May 4, 1908, pp. 1–15.
Mentions *changa* and ants (p. 10) in relation to cane planting.

(28) 1908. TOWER, W. V.
Control of the Brown Ant (*Solenopsis germinata* Fabr.) and the Mealy Bug (*Pseudococcus citri* Risso) in Pineapple Plantations. Circ. 7, P. R. Agr. Exp. Sta., U. S. D. A., Mayagüez, 1908.

(29) 1908. TOWER, W. V.
Report of the Entomologist and Plant Pathologist. *In* Ann. Rept. P. R. Agr. Exp. Sta. for 1907, Mayagüez, May 4, 1908, pp. 31–38.
Discusses Diaprepes (p. 31) and Lachnosterna (p. 32) as citrus pests, *changa* (p. 39) as tobacco pest and mealy bugs (p. 36), *Sphenophorus* sp. and *Xyleborus* sp. (p. 37) as cane pests.

(30) 1908. WHEELER, DR. WM. M.
The Ants of Porto Rico and the Virgin Islands. Bul. Am. Mus. of Nat. Hist., Vol. 24, Feb. 7. 1908, pp. 117–158, pls. 2.

(31) 1909. KIRKALDY, G. W.
A Bibliography of Sugar-Cane Entomology. Exp. Sta.,

H. S. P. A., Div. of Ent., Bul. 8, Honolulu, Dec. 24, 1909, pp. 73.
Lists various publications and articles dealing with P. R. cane pests.

(32) 1909. RHEN, JAMES A. G.
A Catholog of the Orthoptera of Cuba and the Isle of Pines. *In* Second Report, Part 2, Estación Central Agronómica de Cuba, Habana, 1909, pp. 175–226.
Records *Scapteriscus didactylus* Latr. (p. 217) and *Orocharis vaginalis* Saus. (p. 225) as occurring in Porto Rico.

(33) 1909. TOWER, W. V.
Report of the Entomologist. *In* Ann. Rept. P. R. Agr. Exp. Sta. for 1908, Mayagüez, Sept., 1909, pp. 23–28.
Notes Diaprepes and May beetle (p. 25) as citrus pests.

(34) 1910. MAY, D. W.
Sugar Cane in Porto Rico. *In* Bul. 9, P. R. Agr. Exp. Sta., U. S. D. A., Mayagüez, Apr. 1910, pp. 44.
Mentions the *changa* and the white grub as important cane pests, p. 44.

(35) 1910. MOORE, E. L.
Insect Pests and Their Extermination. *In* The Porto Rico Horticultural News, San Juan, Sept. 1910, pp. 134, 143-144.
Discusses the *changa,* p. 143.

(36) 1910. TOWER, W. V.
Report of the Entomologist. *In* Ann. Rept. P. R. Agr. Exp. Sta. for 1909, Mayagüez, Sept., 1910, pp. 24–28.
Discusses injury to cane by Lachnosterna larvæ (p. 25).

(37) 1911. JOHNSTON, J. R.
First Rept. of the Pathologist. *In* Bul. 1, Exp. Sta., P. R S. P. A., Río Piedras, 1911, pp. 35–48.
Mentions white grub and root diseases (pp. 36–37), root diseases and flies (p. 39), red rot and borers (p. 45), and toprot and moth borer (p. 47).

(38) 1911. TOWER, W. V.
Report of the Entomologist. *In* Ann. Rept., P. R. Agr. Exp. Sta. for 1910, Mayagüez, July 17, 1911, pp. 31–34.
Discusses cane insects of Cuba compared with those of Porto Rico, pp. 33–34.

(39) 1911. TOWER, W. V.
Insects Injurious to Citrus Fruits and Methods for Combatting Them. Bul. 10, P. R. Agr. Exp. Sta., U. S. D. A., Mayagüez, May 8, 1911, pp. 35, pls. 5.
Deals with *Diaprepes spengleri* (p. 8), *Lachnosterna*

sp. (p. 10), and *Solenopsis geminata* (p. 11), among citrus pests.

(40) 1911. VAN DINE, D. L.
First Report of the Entomologist. Bul. 1, Exp. Station, P. R. Sugar Growers' Assn., Río Piedras, 1911, pp. 17–31.
Discusses at length *Diatræa saccharalis* Fab. (pp. 19–22), *Lachnosterna* sp. (pp. 22–27), *changa* (pp. 27–29), *Pseudococcus sacchari* (p. 29) and *Metamasius hemipterus* (pp. 29–30).

(41) 1911. VAN DINE, D. L.
The Sugar-Cane Insects of Hawaii. U. S. D. A., Bu. Ent., Bul. 93, June 15, 1911, pp. 54, pls. 4, figs. 5.
Notes *Sphenophorus sexguttatus* Drury (p. 36) (= *Metamasius hemipterus* Linn.) and *Scapteriscus didactylus* (p. 45) as occurring in Porto Rico.

(42) 1912. HOLLOWAY, T. E.
Insects Liable to Dissemination in Shipments of Sugar Cane. U. S. D. A., Bu. Ent., Cir. 165, Dec. 27, 1912, pp. 8.
Notes *Pseudococcus sacchari* (Ckll.) and *Scapteriscus didactylus* Latr. (p. 5) from Porto Rico.

(43) 1912. HOOKER, CHAS. W.
The Ichneumon Flies of America belonging to the tribe Ophionini. Trans. Am. Ent. Soc., Vol. 38, Nos. 1–2, June 12, 1912.
From Porto Rico: *Ophion bilineatus* Say (p. 45) and *Ophiopterus forrugineus* Cress. (pp. 176b–176c, addenda), enemies of cutworms and grass worms.

(44) 1912. JOHNSTON, JOHN R.
Report of the Pathologist. *In* 2nd Ann. Rept., Exp. Sta., P. R. S. P. A., for 1911–1912, Río Piedras, 1912, pp. 23–28.
Discusses work on fungus control of cane insects (p. 27).

(45) 1912. VAN DINE, D. L.
Damage to Sugar-Cane Juice by the Moth Stalk-Borer (*Diatræa saccharalis* Fabr.). Cir. 1, Exp. Sta., P. R. S. P. A., Río Piedras, 1912, pp. 11.

(46) 1912. VAN DINE, D. L.
Progress Rept. on Introductions of Beneficial Parasites into P. R. *In* 1st Rept. Bd. of Comm. Agr. of P. R., period from July 1, 1911 to Jan., 1912, pp. 31–47.
Discusses insect (*Tiphia* and *Pyrgota*) and fungus (*Metarrhizium*) enemies of May-beetles, and the lady-beetle (*Cryptolæmus*) enemy of mealy-bugs.

(47) 1912. VAN DINE, D. L.
Rept. of the Entomologist (2d. Rept.). *In* 2nd Ann.

Rept., Expt. Sta., Sugar Producers' Assn. of P. R., for 1911–12, Río Piedras, 1912, pp. 15–22.

Reports on cane pests, especially moth borer, May-beetle, mealybug and "leaf-hopper" (*Delphax saccharivora* Westw.).

(48) 1912. WALTON, W. R.

A New Species of Tachinidæ from Porto Rico. *In* Proceedings Ent. Soc. of Washington, vol. XIV, No. 4, Jan. 10, 1912, pp. 198–200, pl. X.

Description of *Cryptomeigenia aurifacies* n. sp., reared from the "sugar cane May-beetle."

(49) 1913. BALLOW, H. A.

Root Borers and Other Grubs in West Indian Soils. *In* Agricultural News, Barbados, for Mar. 29 (pp. 106–107), Apr. 12 (p. 122), Apr. 26 (pp. 138–139), May 10 (pp. 154–155). May 24 (pp. 170–171) and June 7, 1913 (p. 186; table).

Includes discussions of known Porto Rican species.

(50) 1913. BALLOU, H. A.

Root Borers and Other Grubs in West Indian Soils. Pamphlet Series No. 73, Imp. Dept. Agr. for W. I., Barbados, 1913, pp. 38, figs. 21.

Reprint of preceding, with illustrations added.

(51) 1913. CARDIN, PATRICIO.

Note (*supplementing* Preliminary Report on the Enemies of Sugar-Cane in Cuba, by J. S. Houser). *In* Estación Experimental Agronómica de Cuba, Cir. 43, Santiago de las Vegas, 1913, pp. 24–29.

States (p. 29) that "el picudo" (*Metamasius sericeus* Oliv.) of the report is the same as that causing great damage in P. R. and Lesser Antilles.

(52) 1913. CROSSMAN, S. S.

"La Changa", *Scapteriscus didactylus*. *In* Second Rept., Board of Comm. Agr. of P. R., 1912–1913, pp. 32–35.

Discusses control as a tobacco pest.

(53) 1913. FELT, E. P.

Three New Gall Midges (Diptera). *In* Canadian Entomologist, Vol. 45, No. 9, Sept. 1913, pp. 304–308.

Describes *Karschomyia cocci* n. sp. from Patillas, P. R., and *Mycodiplosis insularis* n. sp. from Río Piedras, P. R.; reared from mealy-bug on sugar cane and from red-spider.

(54) 1913. HOOD, J. D.

Two New Thysanoptera from Porto Rico. *In* Insecutor Inscitiæ Menstruus, Vol. 1, No. 6, June 1913, pp. 65–70. pl. 1.

Describes *Podothrips semiflavus* n. sp. from *Panicum barbinode* and sugar cane at Guánica, P. R.

(55) 1913. HOOKER, C. W.
Entomological Conferences in Porto Rico. *In* Jl. Econ. Ent., Vol. 6, No. 1, Feb. 1913, pp. 148–150.
Notes briefly papers on May-beetles of P. R. (by D. L. Van Dine), cane aphis (T. H. Jones), the changa (S. S. Crossman), a fungus parasite of cane mealy-bug (R. C. McConnie), and cane insect work at Guánica (T. C. Murphy).

(56) 1913. HOOKER, C. W.
Report of the Entomologist. *In* Ann. Rept., P. R. Agr. Exp. Sta. for 1912, Washington, July 26, 1913, pp 34–38.
Discusses a Tachinid parasite (*Cryptomeigenia* sp.) of May-beetles (p. 35) and attempted use of the fungus, *Metarrhizium anisopliæ,* against May-beetles (pp. 36–37).

(57) 1913. JOHNSTON, J. R.
Report of the Pathologist. *In* 3d. Ann. Rept. (Bul. 5) of Exp. Sta. P. R. S. P. A., Río Piedras, Aug. 1913, pp. 22–24.
Discusses use of Hawaiian beetle fungus against May-beetles (pp. 23–24), and of other fungi against cane pests.

(58) 1913. JONES, T. H.
Some Notes on *Laphygma frugiperda* S. & A. in Porto Rico. *In* Jl. Econ. Ent., Vol. 6, No. 2, April, 1913, pp. 230–236.
Discusses this species and *Remigia repanda* Fab. as cane pests.

(59) 1913. QUAINTANCE, A. L.
Remarks on Some of the Injurious Insects of Other Countries. *In* Proc. Ent. Soc. Washington, Vol. 15, No. 2, June 10, 1913, pp. 54–83.
Mentions from P. R.: *Scapteriscus didactylus* Latr. (p. 57), *Pseudococcus sacchari* Ckll. (p. 63), and *Lachnosterna* spp. (pp. 76–77).

(60) 1913. TOWER, W. V.
Rept. of the Entomologist's Inspection Trip to Santo Domingo. *In* 2nd. Rept., Board Comm. Agr. of P. R., 1912–1913, pp. 25–28.
Supposed identity of several Santo Domingo cane pests with those of Porto Rico.

(61) 1913. VAN DINE, D. L.
The Insects Affecting Sugar Cane in Porto Rico. *In* Jl. Econ. Ent., Vol. 6, No. 2, April, 1913, pp. 251–257.
Resumé of all published information on cane insects of P. R. to that date, with discussion and original observations on each pest.

(62) 1913. VAN DINE, D. L.
The Introduction of Parasites of May-beetles into Porto Rico. *In* Second Rept. Board Comm. Agr. of P. R. for 1912–1913, San Juan, June 30, 1913, pp. 36–48.
Introduction of *Tiphia inornata* cocoons from Illinois (including tables).

(63) 1913. VAN DINE, D. L.
Report of the Entomologist. *In* 3rd. Ann. Rept. Exp. Sta., P. R. S. P. A., Río Piedras, Aug. 1913, pp. 25–46.
List and bibliography of sugar-cane pests in Porto Rico; also account of the rhinoceros beetle and the weevil root-borer.

(64) 1913. VAN DINE, D. L.
Insects Injurious to Sugar-Cane in Porto Rico, and Their Natural Enemies. *In* Jl. Board Agr., Brit. Guiana, Vol. 6, No. 4, pp. 199–203.

(65) 1913. WALTON, W. R.
New North American Tachinidæ (Diptera). *In* Entomological News, Vol. 24, No. 2, Feb., 1913, pp. 49–52, pl. 1.
Description of *Eutrixoides jonesii* gen. et sp. nov., from Porto Rico, reared from *Lachnosterna* (pp. 50–51).

(66) 1913. WOLCOTT, GEORGE N.
Report on a Trip to Demerara, Trinidad and Barbados During the Winter of 1913. *In* 3d Ann. Rept. (Bul. 5), Exp. Sta. P. R. S. P. A., Río Piedras, Aug. 1913, pp. 47–68.
Compares cane pests of these countries with those of Porto Rico.

(67) 1913. WOLCOTT, GEORGE N.
Report on a Trip to Demerara, Trinidad and Barbados During the Winter of 1913. *In* Jl. Econ. Ent., Vol. 6, No. 6 (Dec. 1913), pp. 443–457.
Extract of the preceding article.

(68) 1913. ——— ———.
Useful Birds of Porto Rico. *In* Porto Rico Progress, Vol. 4, No. 13, pp. 13–14. (Noted from Experiment Station Record, Vol. 28, No. 8, June 1913, p. 751.)
Several species of herons found by Biological Survey to destroy *changa*.

(69) 1913. ——— ———.
Destruction of Mole Crickets in Porto Rico by the Heron and Gaulding. *In* The Agricultural News, Barbados, Sept. 27, 1913, p. 314.
Review of article in Exp. Sta. Record for June, 1913.

(70) 1913. ——— ———.
An Entomological Visit to the United States. *In* The Agricultural News, Barbados, Oct. 25, 1913, p. 346.
Includes visit to P. R. and brief discussion of cane pests of the Island.

(71) 1914. BALLOU, H. A.
Insect Pests of Sugar Cane in Antigua and St. Kitts. Pamphlet Series No. 75, Imp. Dept. Agr. for W. I., Barbados, 1914, pp. 45, pl. 1, figs. 20.
Notes *Strategus titanus* (p. 43) and *Diaprepes spengleri* (pp. 41–43) as occurring in P. R.

(72) 1914. JONES, T. H.
Sugar-Cane Insects in Porto Rico. *In* Jl. Econ. Ent., Vol. 8, No. 6, Dec. 1914, pp. 461–463. (See Review Applied Ent., A, III, 3, March 1915, p. 134.)
Discusses known cane insect pests of the Island, including a number not before recorded (*Pseudococcus calceolariæ, Aphis setariæ, Prenes ares, Tetranychus* sp. and 2 species of thrips).

(73) 1914. LENG, CHAS. W., AND MUTCHLER, A. J.
A Preliminary List of the Coleoptera of the West Indies as Recorded to January 1, 1914. Bulletin of Am. Mus. Nat. Hist., Vol. 23, Art. 30, pp. 391–493, New York, Aug. 26, 1914.
Beetles known to attack cane listed from P. R. on pages 442, 454, 469, 478 and 480.

(74) 1914. PIERCE, W. DWIGHT.
Description of Two New Species of Strepsiptera (Halcotophagidæ) Parasitic on Sugar-Cane Insects. *In* Proc. Ent. Soc. Washington, XVI, 3, Sept. 1914, pp. 126–129.
Stenocranus saccharivorus parasitized by *Stenocranophilus quadratus* gen. et sp. nov. at Río Piedras, P. R., in Oct. 1912.

(75) 1914. VAN ZWALUWENBURG, R. H.
Preliminary Check List of Porto Rican Insects, Mayagüez, Sept. 1914, pp. 62. (Additions to same, March 1915, pp. 15.)
Mimeographed list distributed to friends and museums. Cane pests listed, under orders.

(76) 1914. WALTON, W. R.
Four New Species of Tachinidæ from North America. *In* Proc. Ent. Soc. Washington, XVI, 2, pp. 93–95. Washington, June 1914.
Describes two from P. R., *Linnemyia fulvicauda* from *Remigia repanda*, and *Compsilura oppugnator* from *Cirphis latiuscula*.

(77) 1914. WOLCOTT, GEORGE N.
Notes on the Life-History and Ecology of *Tiphia inornata*

Say. *In* Jl. Econ. Ent., Vol. 7, No. 5, Oct. 1914, pp 382–389.
Studies in connection with collection of cocoons for shipment to Porto Rico.

(78) 1914. ——— ———.
Termites or White Ants. *In* Agricultural News, Vol. 13 No. 309, Feb. 28, 1914, p. 74.
States that "the species of *Eutermes* are known to attack cane plants in the field in Antigua and Porto Rico," and lists *E. acagutlas* from P. R.

(79) 1915. Ballou, H. A.
Notes on Porto Rico Insects. *In* The Agr. News, Barbados, Aug. 28, 1915, p. 282.
Reviews Circular 6, P. R. Insular Exp. Sta., on "the *changa*".

(80) 1915. Crossman, S. S., and Wolcott, G. N.
Control of the Changa. Cir. 6, Insular Exp. Sta. of P. R. Río Piedras, 1915, pp. 3.
Recommends a bait of flour and Paris green.

(81) 1915. Fiske, R. J.
Report of the Quarantine Inspection Work. *In* 3d Rept., Board Comm., Agr. of P. R., 1913–1914, San Juan, 1915 pp. 14–19.
Mentions the fire ant (*Solenopsis geminata*) as "a very serious pest to the fruit, coffee, and sugar industry" (p. 19).

(82) 1915. Holloway, T. E.
Fighting the Sugar-Cane Borer with Parasites and Poisons. *In* The Louisiana Planter, Dec. 18, 1915, pp. 397-398.
Discusses the effects of trash burning and of rainfall on Diatræa in Porto Rico.

(85) 1915. Johnston, J. R.
Report of the Work of the Department of Pathology. *In* 3d Report, Board Comm. Agr. of Porto Rico, 1913–1914, San Juan, 1915, pp. 63–64.
Notes an experiment in the use of Green Muscardine fungus to control May-beetles.

(84) 1915. Johnston, John R.
The Entomogenous Fungi of Porto Rico. Bul. 10, Board Comm. Agr. of P. R., Río Piedras, Mar. 15, 1915, pp. 33, pls. 9.
Fungi attacking cane insects: *Agrostalagmus albus* (p. 10), *Aspergillus flavus* (pp. 14–18), *Botrytis rileyi* (pp. 18–19), *Isaria barberi* (pp. 20, 24–25), *Empusa sphærosperma* (pp. 22–23). *Isaria* sp. (pp. 25–26), and *Metarrhizium anisopliæ* (pp. 26–28).

(85) 1915. JONES, THOS. H.
Report of the Department of Entomology. *In* Third Report, Board Comm. Agr. of P. R., 1913–1914, San Juan, 1915, pp. 19–25.
Discusses work on May-beetles and their introduced parasites, and proposed work on other cane pests.

(86) 1915. JONES, T. H.
Aphides or Plant Lice Attacking Sugar-Cane in Porto Rico. Bul. 11, Exp. Sta. of Board Comm. Agr. of P. R., Mar. 15, 1915, pp. 19, pls. 2.
Life-history and habits of *Sipha flava* Forbes and *Aphis setariæ* Thos.

(87) 1915. JONES, T. H.
The Sugar-Cane Moth Stalk-Borer (*Diatræa saccharalis* Fabr.). Bul. 12, Exp. Sta. of Board Comm. Agr. of P. R., Río Piedras, Mar. 16, 1915, pp. 30, figs. 8.
Life-history, parasites, control, etc.

(88) 1915. JONES, THOMAS H.
Insects affecting Vegetable Crops in Porto Rico. Bul. 192, U. S. D. A., Washington, Apr. 8, 1915, pp. 11, pls. 4.
Discusses *Scapteriscus didactylus* Latr. (p. 4), *Diabrotica graminea* Bal. (p. 5), *Laphygma fungiperda* S. & A. (p. 7), and *Solenopsis geminata* Fab. (p. 9) as vegetable pests.

(89) 1915. JONES, THOS. H.
The Sugar-Cane Weevil Root-Borer (*Diaprepes spengleri* L.). Bul. 14, Exp. Sta., Board Comm. Agr. of P. R., Río Piedras, Apr. 14, 1915, pp. 19, figs. 11.
Life-history, habits, parasites, control, etc.

(90) 1915. PIERCE, W. DWIGHT.
Some Sugar-Cane Root-Boring Weevils of the West Indies. *In* Jl. Agr. Research, Vol. 4, No. 3, Washington, June 15, 1915, pp. 255–263, pls. 4.
Groups the forms of *Diaprepes* attacking sugar cane into 2 species, *famelicus* Oliv. and *spengleri* Linn., the latter of them having 6 varieties, 3 of which occur in Porto Rico. Gives briefly control measures.

(91) 1915. SMYTH, E. G.
Report of Work at the South Coast Laboratory. *In* 3d. Report, Board Comm. Agr. of P. R., 1913–1914, San Juan, 1915, pp. 40–53.
Field habits and control of 3 species of *Lachnosterna*, 2 of *Dyscinetus*, 1 of *Ligyrus* and 1 of *Strategus* (cane pests) and release of *Tiphia* wasps from Illinois.

(92) 1915. TOWER, W. V.
Report of the Secretary. *In* Third Report, Board Comm. Agr. of P. R., 1913–1914, San Juan, 1915, pp. 9–13.

Notes work "combating the *changa*" (p. 10), and of the traveling entomologist "obtaining parasites of the white-grub, *changa,* mealy-bug and moth-borer" (p. 11).

(93) 1915. VAN ZWALUWENBURG, R. H.
Report of the Entomologist. *In* Rept. P. R. Agr. Exp. Sta., U. S. D. A., for 1914, Mayagüez, July 10, 1915, pp. 31–35.
Discusses control of *Scapteriscus didactylus* (pp. 31–32), of May-beetles by a bacterium (p. 34), and gives note on *Diaprepes spengleri* (p. 35).

(94) 1915. WOLCOTT, G. N.
Report of the Traveling Entomologist. *In* 3d. Rept., Board Comm. Agr. of P. R., 1913–1914, San Juan, 1915, pp. 25–40.
Introduction of May-beetle parasites from Illinois and account of trips to Cuba and Jamaica to secure cane insect parasites.

(95) 1915. WOLCOTT, GEORGE N.
Influencia de la lluvia y la quemazón de la paja sobre la abundancia de *Diatræa saccharalis.* Cir. 7, Insular Exp. Sta. of P. R., Río Piedras, 1915, pp. 6.

(96) 1916. BALLOU, H. A.
Fighting the Sugar-Cane Borer with Parasites and Poisons. *In* The Agr. News, Barbados, Apr. 22, 1916, pp. 138–139.
Reviews article by Holloway in Louisiana Planter, Dec. 18, 1915. Mentions effects of rainfall on Diatræa in P. R.

(97) 1916. MARSHALL, G. A. K.
On New Neotropical Curculionidæ. *In* Ann. and Mag. Nat. Hist., Vol. 18, No. 108, London, Dec. 1916, pp. 449–468.
Discusses the synonymy of species and varieties of *Diaprepes* characterized by Pierce (Jl. Agr. Research, June 15, 1915).

(98) 1916. MERRILL, G. B.
Report of the Tobacco Insect Investigations. *In* 4th Report, Board Comm. Agr. of P. R., 1914–1915, San Juan, 1916, pp. 50–52.
Discusses control of *changa* (pp. 50–51).

(99) 1916. SMYTH, E. G.
Report of the South Coast Laboratory. *In* 4th Report, Board Comm. Agr. of P. R., 1914–1915, San Juan, 1916, pp. 45–50.
Account of experimental work on white grubs, and table of life-history summaries of 8 species of Scarabæidæ, attacking cane.

(100) 1916. STEVENSON, JOHN A.
Report of the Pathologist. *In* 4th Report, Board Comm. Agr. of P. R., 1914–1915, San Juan, 1916, pp. 33–44.
Work with the Green Muscardine (pp. 34–35).

(101) 1916. TOWER, W. V.
Report of the Secretary and Director. *In* 4th Report, Board Comm. Agr. of P. R., 1914–1915, San Juan, 1916. pp. 9–16.
Notes briefly (p. 11) the year's work on cane pests and *changa.*

(102) 1916. VAN ZWALUWENBURG, R. H.
Report of the Entomologist. *In* Rept. P. R. Agr. Exp. Sta., U. S. D. A., for 1915, Mayagüez, Nov. 23, 1916, pp. 42–45.
Discusses *Scapteriscus didactylus* (p. 42), *Eutermes morio* as a timber pest (p. 43), *Strategus quadrifoveatus* as a coconut pest (p. 44), *Apate francisca* as a mahogany pest (p. 44), and *Sipha flava* on cane (p. 45).

(103) 1916. WETMORE, ALEX.
Birds of Porto Rico. Bul. 326, Bu. Biol. Sur., U. S. D. A., 1916, pp. 140, pls. 10. (=Bul. 15, P. R. Insular Exp. Sta.)
Gives stomach contents of majority of P. R. birds, enumerating cane pests.

(104) 1916. WOLCOTT, GEORGE N.
Report of the Entomologist. *In* 4th Report, Board Comm. Agr. of P. R., 1914–1915, San Juan, 1916, pp. 17–22.
Gives summary of bulletins 11, 12 and 14, dealing with cane pests, by T. H. Jones.

(105) 1916. ——— ———.
The Birds of Porto Rico. *In* the Agricultural News, Barbados, July 1, 1916, p. 219.
Review of Bulletin 326, U. S. D. A., by Alex Wetmore; discusses bird enemies of cane insects in P. R.

(106) 1917. HUTSON, J. C.
Some Weevils of the genus Diaprepes in the West Indies *In* The Agricultural News, Barbados, June 16, 1917, p. 186.
Gives table and distribution of species recently determined by Dr. Pierce.

(107) 1917. HUTSON, J. C.
White Grubs Injuring Sugar-Cane in Porto Rico. *In* The Agricultural News, Barbados, July 14 (pp. 218–219), July 28 (p. 234), and Aug. 11, 1917 (pp. 250–251).
Review and discussion of article of same title by Smyth in Jl. Dept. Agr. of P. R., Vol. 1, No. 2, pp. 47–92.

(108) 1917. HUTSON, J. C.
Sugar-Cane White Grubs in Porto Rico. *In* The Agricultural News, Barbados, Oct. 20, 1917, pp. 330–331.
Review and discussion of article on white-grubs by Smyth in Jour. Dept. Agr. of P. R., Vol. 1, No. 3, pp. 141–169.

(109) 1917. JONES, T. H.
A List of the Coccidæ of Porto Rico. *In* Jl. of Board Comm. Agr. of P. R., Vol. 1, No. 1, Jan. 1917, pp. 1–16.
Lists *Pseudococcus calceolariæ* Mask. (p. 4), *Ps. sacchari* Ckll. (p. 5), *Aclerda tokionis* Ckll. (p. 8) and *Aspidiotus sacchari* Ckll. (p. 12) as cane pests.

(110) 1917. SMYTH, E. G.
The White-Grubs Injuring Sugar-Cane in Porto Rico, Part I, Melolonthids. *In* Jl. Dept. Agr. of P. R., Vol. 1, No. 2, Apr. 1917, pp. 47–92, pls. 8, and Vol. 1, No. 3, July 1917, pp. 141–169.
Researches into the life-history, damage, distribution, parasites, etc., of 4 new species of *Phyllophaga* (=*Lachnosterna*) and 1 new species of *Phytalus*.

(111) 1917. SMYTH, E. G.
The White-Grubs Injuring Cane and Other Crops in Porto Rico. *In* Porto Rico Progress, San Juan, May 18, 1917.
Popular account of their injuries and life-histories.

(112) 1917. SMYTH, E. G.
Report of the Entomological Department. *In* Ann. Rept. Insular Exp. Sta. of P. R., 1916–1917, Río Piedras, 1917, pp. 99–106.
Account of cane insects intercepted from Santo Domingo, and of fumigation of cane steamers (pp. 105–106).

(113) 1917. STEVENSON, J. A.
Report of the Pathologist. *In* 5th Report, Board Comm. Agr. of P. R., 1915–1916, San Juan, 1917, pp. 35–74.
States (p. 68) that moth stalk-borer larvæ pass through uninjured when cane trash is burned.

(114) 1917. STEVENSON, JOHN A.
Report of the Department of Pathology and Botany. *In* Ann. Rept., Insular Exp. Sta. of P. R., 1916–1917, Río Piedras, 1917, pp. 37–98.
Notes (p. 56) injury to cane experiments by *Diatræa*, *Diaprepes spengleri* and *Phyllophaga* spp.

(115) 1917. TOWER, W. V.
Report of the Director. *In* 5th Report, Board Comm. Agr. of P. R., 1915–1916, San Juan, 1917, pp. 9–15.
Notes briefly work on *Diatræa saccharalis* (p. 14) and on *changa* (p. 15).

(116) 1917. VAN ZWALUWENBURG, R. H.
Insects Affecting Coffee in Porto Rico. *In* Jl. Econ. Ent., Vol. 10, No. 6, Dec. 1917, pp. 513–517.
Discusses: *Apate fransisca* Fab. (p. 516) and the May-beetles and their two Tachinid parasites (p. 517).

(117) 1917. WOLCOTT, G. N
Report of the Entomologist. *In* 5th Report, Board Comm. Agr. of P. R., 1915–1916, San Juan, 1917, pp. 75–85, pl. 1.
Effect of rainfall and trash burning upon infestation of cane by *Diatræa saccharalis* (pp. 80–85).

(118) 1918. COTTON, R. T.
Experimental Work on the Control of the White Grubs of Porto Rico. *In* Jl. Dept. Agr. of P. R., Vol. 2, No. 1, Jan. 1918, pp. 1–18.
Deals with the larvæ of *Phyllophaga,* mainly as sugar-cane pests. Summarizes work of other investigators.

(119) 1918. COTTON, R. T.
Medios para Combatir los Gusanos Blancos. Cir. 12, Insular Exp. Sta. of P. R., Río Piedras, 1918, pp. 7.
Control measures for white-grubs.

(120) 1918. COTTON, R. T.
Insects Attacking Vegetables in Porto Rico. *In* Jl. Dept. Agr. of P. R., Vol. 2, No. 3, Oct. 1918, pp. 265–317, figs. 67.
Discusses: *Changa* (p. 270), grasshoppers (p. 272), white-grubs (p. 274), *Laphygma frugiperda* (p. 288), *Diatræa saccharalis* (p. 290), fire ant (p. 296), and *Diabrotica graminea* (p. 302).

(121) 1918. HUTSON, J. C.
The Production of Light in Certain Animals. *In* The Agricultural News, Barbados, Jan. 12, 1918, pp. 10–11.
Mentions larvæ of *Pyrophorus luminosus* as predacious on white-grubs in cane fields in P. R.

(122) 1918. HUTSON, J. C.
The West Indian Mole Cricket or *Changa*. *In* The Agricultural News, Barbados, Apr. 6, 1918 (pp. 106–107, fig. 1), and Apr. 20, 1918 (p. 122).
Review and discussio[illegible]l. 23, P. R. Agr. Exp. Sta., U. S. D. A.

(123) 1918. STEVENSON, J. A.
The Green Muscardine Fungu[illegible]orto Rico. *In* Jl. Dept. Agr. of P. R., Vol. 2, No. [illegible]1918, pp. 19–32, pl. 1.
Twenty-one out of 29 r[illegible]d insect hosts are cane pests.

(124) 1918. STEVENSON, J. A.
A Check List of Po[illegible] Rican F[illegible]ngi and a Host Index. *In*

Jl. Dept. Agr. of P. R., Vol. 2, No. 3, July 1918, pp. 125–264.

Fungi attacking cane insects, pp. 134, 207, 208 and 218.

(125) 1918. VAN ZWALUWENBURG, R. H.
Report of the Entomologist. *In* Rept., P. R. Agr. Exp. Sta., U. S. D. A., for 1916, Mayagüez, Feb. 5, 1918, pp. 25–28, pl. 1.

Discusses light trapping of May-beetles (pp. 25, 26), *Scapteriscus vicinus* (p. 25), and *Sipha flava* (p. 28). States that termite previously reported as *Eutermes morio* is *Cryptotermes* sp.

(126) 1918. VAN ZWALUWENBURG, R. H.
The Changa or West Indian Mole Cricket. Bul. 23, P. R. Agr. Exp. Sta., U. S. D. A., Mayagüez, Feb. 12, 1918, pp. 28, pls. 3.

Considered "the most serious insect pest of general agriculture in Porto Rico." Bibliography of 54 titles appended.

(127) 1918. VAN ZWALUWENBURG, R. H.
Some Means of Controlling Insects, Fungi, and Other Pests in Porto Rico. Cir. 17, P. R. Agr. Exp. Sta., U. S. D. A., Mayagüez, June 27, 1918, pp. 30.

Includes special control measures for cut-worms, *changa,* fire-ant, etc.

(128) 1918. VAN ZWALUWENBURG, R. H.
Report of the Entomologist. *In* Rept. P. R. Agr. Exp. Sta., U. S. D. A., for 1917, Mayagüez, Sept. 20, 1918, pp. 33–34.

Notes light trapping of *changas, Strategus quadrifoveatus* as a coconut pest, and tests of cyanamid as remedy for white grubs (p. 34).

(129) 1919. BALLOU, H. A.
The Toad in the West Indies. *In* The Agricultural News, Barbados, Nov. 29, 1919, pp. 378–379.

Discusses the proposed introduction of toads into Porto Rico to combat white-grubs (see number 132, this list).

(130) 1919. COLÓN, E. D.
Report of the Director. *In* Ann. Rept., Insular Exp. Sta. of P. R. for June 30, 1918, Río Piedras, 1919, pp. 6–77.

Review of entomological work from 1913 to 1918, pp. 8–13; 29–59. Cane pests, pp. 8, 29–30, 32–33, 37–58.

(131) 1919. HOLLOWAY, T. E. AND LOFTIN, U. C.
The Sugar-Cane Moth Borer. Bulletin No. 746, U. S. D. A., Washington, Apr. 18, 1919, pp. 74, pls. 10, figs. 12.

Mentions climatic and fungus control (pp. 35–38) and parasites (p. 41) of Diatræa in Porto Rico.

(132) 1919. SMYTH, E. GRAYWOOD.
Report of the Division of Entomology. *In* Ann. Rept., Insular Exp. Sta. of P. R. for June 30, 1918, Río Piedras, 1919, pp. 109–129.
Insect transmission of cane mottling disease (pp. 118–119), cane white-grub problem (pp. 119–120), hard-backs injuring cane (pp. 120–121), red-spider attacking cane (pp. 121–122), epidemic of yellow cane aphis (pp. 122–123), and *Eutermes morio* (pp. 126–127).

(133) 1919. SMYTH, E. GRAYWOOD.
Report of the Entomologist. *In* Ann. Rept., Insular Exp. Sta. of P. R. for year ending June 30, 1919, Río Piedras, 1919, pp. 27–31.
Work on the transmission of the sugar-cane mottling disease by insects, pp. 28–30.

(134) 1919. SMYTH, E. GRAYWOOD.*
[Work of the] Division of Entomology. *In* Report of the Commisioner of Agr. and Labor of P. R., Bureau of Insular Affairs, War Dept., Washington, 1919, pp. 685–713.
Mentions *Bothriocera* sp. as feeding on cane (p. 695), and discusses successful transmission of the cane mottling disease (p. 699) by means of *Stenocranus saccharivorus* Westw. and *Aclerda tokionis* Ckll. (the latter being a misdetermination for *Pulvinaria iceryi* Guer.).

(135) 1919. ——— ———.
Entomology in Porto Rico. *In* The Agricultural News, Barbados, Nov. 15, 1919, pp. 362–363.
Review of the entomologist's report (Ann. Rept. P. R. Insular Exp. Sta.) for year ending June 30, 1918.

(136) 1919. ——— ———.
Skunks and Toads—A Warning. *In* The Agricultural News, Barbados, Nov. 15, 1919, p. 361.
Discussion of proposed introduction of skunks and toads into P. R. to combat white-grubs.

* The following paragraphs of this report: Plant Quarantine (pp. 691–692), Division of Entomology (p. 694), Work on Citrus Insect Pests (p 695) and Entomological Work (on Yellow-Stripe Diseases) (p. 699), though not credited to the writer, are taken verbatim from his annual report, and were unfortunately omitted from the Annual Report of the Experiment Station for the same year.

LIST OF THE INSECT AND MITE PESTS OF SUGAR CANE IN PORTO RICO.[1]

By E. Graywood Smyth.

I. ACARINA.

1. *Oligonychus viridis?* (family Tetranychidæ).

Common Name: Sugar-cane red-spider.
Damage: Attacks leaves, especially undersides, causing white marks by extraction of chlorophyll.
Distribution: Probably entire Island.
Food Plants: Sugar cane and grasses.
Enemies: A Cecidomyid fly; a Coccinellid and a Staphylinid beetle; and *Franklinothrips vespiformis.*
Control: Dusting or spraying with sulphur mixtures; heavy infestation uncommon, hence spraying unnecessary.

2. *Uropodus* sp. (undetermined) (family Uropodidæ).

Common Name: Sugar-cane root mite.
Damage: Eats into, severs, and sometimes tunnels the roots. Damage sometimes serious.
Distribution: North coast; possibly entire Island.
Food Plants: Sugar cane; other hosts not observed.
Enemies: None thus far recorded.
Control: Crop rotation; maintenance of vigorous growth.

3. *Tarsonemus spinipes* Hirst (family Tarsonemidæ).

Common Name: Sugar-cane rust mite.
Damage: Forms flat, rusty-brown blisters on stem and leaf sheathes.
Distribution: Entire Island; other West Indies.
Food Plants: Sugar cane; no others known.
Enemies: None recorded.
Control: Dipping seed in lime-sulphur solution, or other strong disinfectant; clean cultivation between crops.

[1] This list includes all the insects that have been found repeatedly feeding upon the cane plant, *Saccharum officinarum,* though a considerable number of them have not been found breeding on cane. Lack of time has prevented the making or securing of accurate determinations in many cases. Distribution and food plants, of species occurring also in other localities, have been taken from such sources as were available. The author acknowledges having made free use of previous lists published by Messrs. Van Dine and Jones, former entomologists of this Station. There are twenty-six species in the present list which have not been previously recorded to the writer's knowledge as attacking sugar cane in Porto Rico.

The orders have been arranged according to Brues and Melander, the families according to Banks in the Acarina, Scudder in the Orthoptera, Blatchley and Leng in the Coleoptera, Dyer in the Lepidoptera, and Van Duzee in the Homoptera.

II. ORTHOPTERA.

4. *Schistocera pallens* Thunb. family Acrididæ).
   COMMON NAME: Larger field grasshopper.
   DAMAGE: Nymphs and adults attack foliage.
   DISTRIBUTION: South coast; other West Indies; South America.
   FOOD PLANTS: Sugar cane, field crops, grass, etc.
   ENEMIES: Animal—Birds; mangoose; lizards; tree frogs.
   Arthropod—Tarantula; centipede; Bombyiid fly; certain wasps; a Cicindellid (*Tetracha*).
   Fungus—Possibly *Botrytis rileyi*.
   CONTROL: Use of poison baits; night collection with lanterns; arsenical sprays on foliage where live stock do not have access.
5. *Schistocerca columbina* Brunn. (family Acrididæ).
   COMMON NAME: Common field grasshopper.
   DAMAGE: Attacks foliage, eating edges of leaves.
   DISTRIBUTION: Entire Island; other West Indies; Central and South America.
   FOOD PLANTS: Sugar cane, grass, and many crops.
   ENEMIES: Same as those of preceding species.
   CONTROL: Same as for preceding.
6. *Plectrotettix* (*Scyllina*) *gregarius* Walk. (fam. Acrididæ).
   COMMON NAME: Green-back grasshopper.
   DAMAGE: Attacks foliage; may become injurious when very abundant.
   DISTRIBUTION: Entire Island; St. Thomas; Haiti.
   FOOD PLANTS: All tender green vegetation.
   ENEMIES: The same as those of Schistocerca.
   CONTROL: By use of poison baits, or arsenical spraying.
7. *Sphingonotus haitensis* Sauss. (family Acrididæ).
   COMMON NAME: Dusky ground grasshopper.
   DAMAGE: Eats foliage, especially of young cane.
   DISTRIBUTION: Porto Rico; Haiti; Cuba; Mexico.
   FOOD PLANTS: Any vegetation growing close to ground.
   ENEMIES: Same as of those preceding.
   CONTROL: By use of poison baits.
8. *Neoconocephalus* (*Conocephalus*) *mexicanus* Sauss. (family Tettigoniidæ).
   COMMON NAME: Green cone-headed katydid.
   DAMAGE: Attacks foliage; splits leaf in laying eggs.
   DISTRIBUTION: Greater Antilles; southern U. S.; Mexico; Central and South America.
   FOOD PLANTS: Sugar cane; grasses; many crops and trees.
   ENEMIES: Animal—Mongoose; birds; lizards; tree frogs.
   Arthropod—Centipede; large spiders; wasps.
   Fungus—None recorded.
   CONTROL: Arsenical sprays; trap lights at night.

9. *Neoconocephalus cinereus* Thunb. (family Tettigoniidæ).
COMMON NAME: Brown cone-headed katydid.
DAMAGE: Both nymph and adult eat foliage.
DISTRIBUTION: Porto Rico; Jamaica.
FOOD PLANTS: Sugar cane and other vegetation.
ENEMIES: Same as those of *N. mexicanus*.
CONTROL: Arsenical sprays and trap lights.

10. *Microcentrum triangulatum* Brunn. (family Tettigoniidæ).
COMMON NAME: Broad-winged katydid.
DAMAGE: Eats the foliage; less common on cane than two preceding species.
DISTRIBUTION: Porto Rico; St. Thomas; Guadaloupe.
FOOD PLANTS: Sugar cane; citrus; many other crops.
ENEMIES: Same as those of preceding.
CONTROL: Arsenical sprays and trap lights.

11. *Cyrtoxiphus gundlachi* Sauss. (family Gryllidæ).
COMMON NAME: Little green tree-cricket.
DAMAGE: Always present on foliage; extent of injury not known. Eats the parenchyma of leaf, apparently.
DISTRIBUTION: Porto Rico; Cuba; Jamaica; southern U. S.; Mexico; St. Vincent; Nicaragua; Brazil.
FOOD PLANTS: Sugar cane; citrus; banana; most crops.
ENEMIES: Birds, lizards, tree-frogs, spiders and predacious bugs. No parasites yet recorded.
CONTROL: Amenable to contact sprays.

12. *Orocharis vaginalis* Sauss. (family Gryllidæ).
COMMON NAME: Brown tree-cricket.
DAMAGE: Conceals in terminal leaf coil and injures tender foliage.
DISTRIBUTION; Porto Rico; Santo Domingo; Cuba.
FOOD PLANTS: Sugar cane, citrus, and other crops.
ENEMIES: Same as of preceding species.
CONTROL: Light traps; arsenicals applied to foliage.

13. *Scapteriscus vicinus* Scud. (family Gryllotalpidæ).
COMMON NAME: *Changa*, or mole-cricket.
DAMAGE: Attacks roots and buds; damage very severe in sandy soils.
DISTRIBUTION: Greater and Lesser Antilles; south-eastern United States; Central and South America.
FOOD PLANTS: Sugar cane; lawn grass; all cultivated crops.
ENEMIES: Animal—Birds; lizards, especially the ground lizard, *Ameiva exul;* the mangoose.
Arthropod—Tarantula; centipede; the fire-ant; a wasp (Garrinæ); *Tetracha infuscata*.
Fungus—None known.
CONTROL: Poison baits (Paris green and flour; phosphorus and corn meal; white arsenic, molasses and dry manure); trap lights; protection of ground lizard; sprinkling ground with strong soap solution; planting cane with part of eyes above ground.

III. THYSANOPTERA.

14. *Frankliniella* sp. (family Thripidæ).
    COMMON NAME: Yellow cane thrips.
    DAMAGE: Works and breeds between coiled terminal leaves, scarifying leaf surface. Suspected of transmitting the mottling disease.
    DISTRIBUTION: Abundant on south coast, less so on north side of Island.
    FOOD PLANTS: Sugar cane; possibly some wild grasses.
    ENEMIES: Predacious bug, near Triphleps; probably also Coccinellids, and predacious thrips.
    CONTROL: Spraying with contact poisons; covering young plants, before attack, with bunting cloth; clean cultivation between crops.
15. *Haplothrips* (?) *tibialis* Hood. ? (family Thripidæ).
    COMMON NAME: Black cane thrips.
    DAMAGE: Works and breeds near tips of leaves of young cane, causing some spotting. Damage not severe.
    DISTRIBUTION: North coast, so far as recorded.
    FOOD PLANTS: Sugar cane and grasses
    ENEMIES: *Franklinothrips vespiformis.*
    CONTROL: Not sufficiently injurious to require control.
16. *Podothrips semiflavus* Hood. (family Thripidæ?).
    COMMON NAME: Thrips.
    DAMAGE: Works between leaves; collected by T. H. Jones.
    DISTRIBUTION: Recorded from south coast of Island.
    FOOD PLANTS· Sugar cane and Para grass
    ENEMIES: None recorded.
    CONTROL: Not required.

IV. ISOPTERA.

17. *Eutermes morio* Lath. (family Termitidæ).
    COMMON NAME: Termite, white-ant, or "comején."
    DAMAGE: Sometimes riddles the seed-cane in the soil. Rarely attacks standing cane.
    DISTRIBUTION: Entire Island.
    FOOD PLANTS: Partly dry cane stalks; bark of trees; dead wood; timbers.
    ENEMIES: Lizards; birds (eat the flying form); bats; no others observed.
    CONTROL: London purple or white arsenic powder on nest; kerosene; coal-tar creosote and kerosene; mercury bichlorid dissolved in water; white arsenic and washing soda boiled together, mixed with distillate; fumigation.

V. HYMENOPTERA.

18. *Solenopsis geminata* Fabr. (family Formicidæ).
    COMMON NAME: Fire-ant, or "hormiga brava."

DAMAGE: Injures cane indirectly by sheltering mealybugs and aphids from their enemies; also a menace to cane cutters. Causes lesions where fingi may enter.

DISTRIBUTION: Practically entire Western Hemisphere, in warmer climates.

FOOD PLANTS: No direct injury to cane, but injures citrus, cowpeas, egg-plants, banana trees, etc.

ENEMIES: None recorded.

CONTROL: Spraying with kerosene emulsion recommended; crop rotation and clean cultivation best means. London purple can be sprinkled on ant hills.

VI. COLEOPTERA.

19. *Apate francisca* Fab. (family Bostrychidæ).

COMMON NAME: Rough-headed stem borer.

DAMAGE: Riddles the standing stalks (rarely).

DISTRIBUTION: Entire Island.

FOOD PLANTS: Coffee, citrus, mahogany, flamboyant, chinaberry, *Salix humboldtiana,* Casuariana, Picramnia, Prosopis, gandule bean and sugar cane.

ENEMIES: Birds and lizards; no insect enemies recorded.

CONTROL: Drop carbon bisulphide into burrow and plug entrance; extirpate and burn infested plants.

20. *Phyllophaga vandinei* Smyth (Scarabæidæ).

COMMON NAME: Sugar-cane white-grub (May beetle; "caculo").

DAMAGE: Larvæ eat roots to great extent; costs one sugar "central" over a thousand dollars per annum to control.

DISTRIBUTION: Western third of Island.

FOOD PLANTS: Grubs eat all roots; adults nearly all foliage.

ENEMIES: Animal—Blackbirds; other birds; mongoose; the larger lizards; chickens; hogs; rats and mice.
Arthropod—Centipede; tarantula; larger spiders; *changa* (of eggs and larva); Scoliid wasps(?); larva of Pyrophorus; 2 Tachinid flies.
Fungus—*Metarrhizium anisopliæ.*
Bacterial—*Micrococcus nigrofaciens.*

CONTROL: Night collection of adults from foliage, or by shaking from trees and bushes onto sheets, and collection of grubs at plowing; protection of blackbirds by banding palm trees against rats; introduction of toads and skunks.

21. *Phyllophaga portoricensis* Smyth (family Scarabæidæ).

COMMON NAME: Common white-grub.

DAMAGE: Grubs attack the roots; adults do injury to foliage when abundant.

DISTRIBUTION: Eastern two-thirds of Island; Vieques.

Food Plants: Roots of all crops; foliage of many plants, especially flamboyant, palms, and banana trees.

Enemies: The same as those of *P. vandinei*.

Control: Same as for preceding species.

22. *Phyllophaga guanicana* Smyth (family Scarabæidæ).

Common Name: Guánica white-grub.

Damage: Grubs attack roots, adults foliage. Not so injurious as *P. vandinei*.

Distribution: Guánica district of the Island.

Food Plants: Grubs attack all roots, indifferently; adults prefer foliage of certain trees.

Enemies: The same as those of *P. vandinei*.

Control: Same as for preceding species.

23. *Phyllophaga citri* Smyth (family Scarabæidæ).

Common Name: Citrus white-grub.

Damage: Grubs attack roots of all crops; adults eat foliage.

Distribution: Entire Island except southwest corner; also Vieques.

Food Plants: Grubs eat roots of all crops; adults prefer foliage of citrus, guava, Acalypha, young palms, and Malvaceæ.

Enemies: The same as those of *P. vandinei*.

24. *Phytalus insularis* Smyth (family Scarabæidæ).

Common Name: Little brown May-beetle.

Damage: Attacks cane roots, but seldom to injurious extent.

Distribution: Entire Island.

Food Plants: Grubs probably eat all roots; adults prefer foliage of grass, corn, Lantana, amaranth, and certain shrubs.

Enemies: Animal—Same as those of *P. vandinei*.
Arthropod—Same as preceding, with exception of Tachinid flies.
Fungus and bacterial—Same as of Phyllophaga.

25. *Dyscinetus* (*Chalepus*) *trachypygus* Burm. (family Scarabæidæ).

Common Name: Dull black hard-back (in U. S.; the rice grub).

Damage: Adults injure seed-cane and buds; larvæ bore into underground stalks.

Distribution: Greater Antilles; southeastern United States.

Food Plants: Sugar cane, grasses, and root crops.

Enemies: Same as those of May-beetle; except Tachinid flies.

Control: Trap lights; poison baits; clean cultivation.

26 *Dyscinetus barbatus* Fabr. (family Scarabæidæ).

Common Name: Shining black hard-back.

Damage: Adults and larvæ injure the underground stems, when abundant.

Distribution: Porto Rico; possibly other Greater Antilles; Barbuda; St. Kitts.

FOOD PLANTS: Sugar cane, grasses and root crops.
ENEMIES: Animal—Same as those of Phyllophaga.
Arthropod—Centipede; tarantula; larger spiders; *changa* (of eggs and larvæ); larva of *Pyrophorus luminosus;* possibly Scoliid wasps.
Fungus—*Metarrhizium anisopliæ.*
CONTROL: Trap lights; poison baits; clean cultivation and deep plowing; cultivation of grass land.

27. *Ligyrus tumulosus* Burm. (family Scarabæidæ).
COMMON NAME: Brown hard-back.
DAMAGE: Adults injure stem and buds at surface of ground; larvæ bore underground stems.
DISTRIBUTION: Greater Antilles; St. Vincent; Nevis; Guadaloupe; St. Bartholomew; Barbados; Trinidad.
FOOD PLANTS: Sugar cane; grasses; root crops; breeds in decaying organic matter.
ENEMIES: Animal—Birds; bats; mongoose; larger lizards; poultry; hogs; rats and mice.
Arthropod—Centipede and tarantula; larger spiders; *changa; Pyrophorus luminosus; Campsomeris dorsata.*
Fungus—*Metarrhizium anisopliæ.*
CONTROL: Poisoned green manure plowed under; poisoned mash baits; trap lights; avoidance of organic fertilizers; destruction of grubs in manure heaps; frequent and deep cultivation.

28. *Strategus quadrifoveatus* Beauv. (family Scarabæidæ).
COMMON NAME: Coconut rhinoceros beetle.
DAMAGE: Adults occasionally tunnel stems of standing cane, to such extent that the cane falls over.
DISTRIBUTION: Porto Rico; Santo Domingo; Haiti.
FOOD PLANTS: Adults feed on sugar cane and young palms; larvæ mature in rotting wood.
ENEMIES: Animal—Herons; owls; mongoose; hogs and poultry; rats.
Arthropod—None thus far recorded.
Fungus—Green Muscardine fungus.
CONTROL: Collection in evening by boys with nets; light traps; trash (dead wood) traps for grubs; use of Green Muscardine in trash traps; poison bait.

29. *Strategus titanus* Fabr. (family Scarabæidæ).
COMMOON NAME: Sugar-cane rhinoceros beetle.
DAMAG5: Larvæ bore in "cepas" (underground stems) and decrease sap flow.
DISTRIBUTION: Porto Rico; Jamaica; Cuba; Vieques; Virgin Islands.
FOOD PLANTS: Larvæ eat cane stalks, also rotting wood.
ENEMIES: The same as those of *S. quadrifoveatus.*
CONTROL: Same as for preceding species.

30. *Diabrotica graminea* Balz. (family Chrysomelidæ).
COMMON NAME: Green flower-beetle.
DAMAGE: Adults feed to some extent upon the foliage, and larvæ upon the roots.
DISTRIBUTION: Entire Island.
FOOD PLANTS: Flowers and foliage of many plants, including most vegetables as well as sugar cane.
ENEMIES: Animal—Birds; lizards; tree-frogs.
Arthropod—Spiders; ants; predacious bugs; *changa* (eats the larvæ).
Fungus—None recorded.
CONTROL: Spraying trap crops with arsenicals; sweeping foliage with nets or with tarred frames; shaking beetles from trap crops like okra or Cleome.

31. *Diaprepes spengleri* Linn. (family Curculionidæ).
COMMON NAME: Sugar-cane root-weevil.
DAMAGE: Larvæ bore large roots and bases of stalks; adults eat foliage to some extent.
DISTRIBUTION: Porto Rico; Vieques.
FOOD PLANTS: Sugar cane, citrus, Leguminosæ, Malvaceæ, and many other cultivated crops.
ENEMIES: Animal—Mongóose; birds; lizards; frogs.
Arthropod—Centipede; spiders; *changa* (eats larvæ); fire-ant. No parasites recorded.
Fungus—Metarrhizium.
CONTROL: Shaking from foliage (citrus) onto sheets, then destroying; turning hogs into cane fields at plowing, to consume stubble; poisinging of trap crops with arsenicals; frequent shallow plowing when possible; heavy fertilization of plants.

32. *Metamasius hemipterus* Linn. (family Curculionidæ).
COMMON NAME: Sugar-cane stalk-weevil.
DAMAGE: Larvæ bore and breed in cane stalks.
DISTRIBUTION: Porto Rico; Virgin Islands; Windward Islands; Demerara.
FOOD PLANTS: Sugar cane; dead or injured palm trunks; banana trunks (rarely). Adults sometimes attack fruit.
ENEMIES: Animal—Same as preceding.
Arthropod—Centipede and spiders. No insect enemies recorded, except the fire-ant.
Fungus—Green Muscardine.
CONTROL: Destruction of infested canes; cutting cane close to ground (as beetle breeds abundantly in stubble); destruction of adults by means of trap piles of decayed fruit or peels.

33. *Xyleborus* sp. (possibly *X. perforans* Woll.) (family Ipidæ).
COMMON NAME: Sugar-cane shot-hole borer.
DAMAGE: Perforates standing stalks; also attacks seed cane in the ground.

DISTRIBUTION: Entire Island.
FOOD PLANTS: Sugar cane; no others recorded with certainty.
ENEMIES: Animal—Birds; bats; lizards.
Arthropod—Spiders; predacious bugs; ants.
Fungus—None recorded.
CONTROL: Destruction of infested canes; trap lights; deep planting and prompt planting of seed.

VII. LEPIDOPTERA.

34. *Prenes nero* Fabr. (family Hesperidæ).
COMMON NAME: Sharp-headed cane leaf-roller.
DAMAGE: Attacks foliage of young cane in larval stage.
DISTRIBUTION: Entire Island.
FOOD PLANTS: Sugar cane and grasses.
ENEMIES: Animal—Birds; lizards; frogs.
Arthropod—Ants; predacious bugs; a Braconid wasp.
Plant—A bacterial disease.
CONTROL: Spraying foliage with arsenicals.

35. *Prenes ares* Feld. (family Hesperidæ).
COMMON NAME: Round-headed cane leaf-roller.
DAMAGE: Larva attacks foliage; less common than preceding.
DISTRIBUTION: Entire Island.
FOOD PLANTS: Sugar cane and grasses.
ENEMIES: Same as those of preceding.
CONTROL: Not required.

36. *Atrytone vitellius* Fabr. (family Hesperidæ).
COMMON NAME: Smaller sugar-cane leaf-roller.
DAMAGE: Eats the margins of leaves, and conceals by tying edges of leaf together.
DISTRIBUTION: Entire Island.
FOOD PLANTS: Sugar cane, Sudan grass and wild grasses.
ENEMIES: These have not been studied.
CONTROL: Same as for species of Prenes.

37. *Laphygma frugiperda* S. & A. (family Noctuidæ).
COMMON NAME: Southern grass-worm.
DAMAGE: Larvæ attack young cane in terminal bud.
DISTRIBUTION: West Indies; United States; Mexico; Central and South America.
FOOD PLANTS: Sugar cane; corn; grass; vegetables; tomato fruit; truck crops.
ENEMIES: Animal—Birds; lizards; frogs; bats.
Arthropod—Ants, predacious bugs; wasps; *Ophion* sp.; *Chelonus* sp.; a Braconid; several Tachinids; *Calosoma alternans*.
Plant—Three fungi, *Botrytis rileyi*, *Empusa sphærosperma*, and *Cordyceps* sp.

CONTROL: Spraying or dusting with arsenicals; frequent cultivation to destroy pupæ.

38. *Cirphis* (*Heliophila latiuscula*) H. S. (family Noctuidæ).
COMMON NAME: Sugar-cane cutworm.
DAMAGE: Larvæ eat the foliage.
DISTRIBUTION: Entire Island; Santo Domingo.
FOOD PLANTS: Sugar cane, sorghums and grasses.
ENEMIES: Animal—Birds; bats; lizards; frogs.
Arthropod—Ants; predacious bugs, wasps; a Braconid and a Chalcidid; several Tachinids.
Plant—Green fungus, *Botrytis rileyi* and *Cordyceps* sp.
CONTROL: Not required.

39. *Mocis* (*Remigia*) *repanda* Fabr. (family Noctuidæ).
COMMON NAME: Grass looper.
DAMAGE: Larvæ attack foliage of young cane.
DISTRIBUTION: West Indies; eastern U. S.; South America.
FOOD PLANTS: Sugar cane and grasses.
ENEMIES: Animal—Same as of preceding.
Arthropod—Spiders, ants, predacious bugs and wasps; an Ichneumonid; a Braconid; a Tachinid.
Fungus—*Botrytis rileyi* and *Cordyceps* sp.
CONTROL: Not required, as attack to cane is uncommon.

40. *Diatræa saccharalis* Fabr. (family Pyralidæ).
COMMON NAME: Sugar-cane moth stalk-borer.
DAMAGE: Larvæ bore the stalk, weaken plant and reduce sucrose.
DISTRIBUTION: West Indies; southern U. S.; Mexico; Central and South America.
FOOD PLANTS: Sugar cane; corn; sorghum; Paspalum; rice.
ENEMIES: Animal—Same as those of the grass-worm.
Arthropod—Spiders; predacious bugs; a Tachinid fly; egg parasite, *Trichogramma minutum* Riley.
Fungus—*Isaria* (*Cordyceps*) *barberi.*
CONTROL: Prompt and regular uprooting and burning of deadhearts; discontinuance of trash burning; destruction of wild Paspalum grass; selection of seed; deep planting of seed; trap lights.

41. *Pyralid* (undetermined) (family Pyralidæ).
COMMON NAME: Sudan grass leaf-tyer.
DAMAGE: Larvæ have been found attacking cane leaves; damage to cane rare.
DISTRIBUTION: Probably entire Island.
FOOD PLANTS: Sugar cane; Sudan grass; other grasses.
ENEMIES: No parasites yet observed.
CONTROL: None required.

42. *Ereunitis* sp. (?) (family Tineidæ).
COMMON NAME: Sugar-cane bud-moth.
DAMAGE: Larvæ bore through buds into stalk; occasionally severe.
DISTRIBUTION: Entire Island.
FOOD PLANTS: Sugar cane; no others recorded.
ENEMIES: No parasites thus far observed.
CONTROL: None yet worked out; seldom required. Time of planting affects the amount of infestation.

VIII. DIPTERA.

43. *Chætopsis* sp. (near *C. ænea* Wied.) (family Ortalidæ).
COMMON NAME: Ear-corn maggot.
DAMAGE: Infests tunnels of Diatræa in the stalk, also leaf sheaths infested with mealybug, inducing progressive decay.
DISTRIBUTION: Entire Island.
FOOD PLANTS: Sugar cane tissue; worm-infested corn ears; decaying coconut fiber; etc.
ENEMIES: A Cynipid parasite observed; spiders; ants.
CONTROL: None usually required.
44. *Agromyza* sp. (undetermined) (family Agromyzidæ).
COMMON NAME: Cane and grass leaf-miner.
DAMAGE: Rarely mines the leaves of young cane; commonly mines grass leaves.
DISTRIBUTION: Probably entire Island.
FOOD PLANTS: Sugar cane, sorghum and grasses.
ENEMIES: Small Chalcidid wasp attacks larva and a Cynipid the pupa.
CONTROL: None required.

IX HOMOPTERA.

45. *Cicadella* (*Tettigonia*) *sirena* Stal. (family Cicadellidæ).
COMMON NAME: Red-striped leafhopper.
DAMAGE: Adult and nymph occasionally attack cane; reared from cane.
DISTRIBUTION: Entire Island.
FOOD PLANTS: Sugar cane; citrus; coffee; sesame; garden plants.
ENEMIES: Animal—Birds; lizards; tree frogs.
Insect—*Conocephalus* (*Xiphidion*) sp.; predacious bugs. No parasites yet recorded.
Fungus—None yet recorded.
CONTROL: Not necessary.
46. *Kolla* (*Tettigonia*) *similis* Walk. (subfamily Cicadellinæ).
COMMON NAME: Green sugar-cane leafhopper.
DAMAGE: Sometimes abundant on young cane, but not directly injurious. Might transmit disease.
DISTRIBUTION: Greater Antilles; southeastern U. S.

FOOD PLANTS: Sugar cane; Para grass; some other grasses.
ENEMIES: Animal—Birds, lizards and tree frogs.
Insect—*Xiphidion* (?); *Zelus rubidus;* a Hymenopterous egg parasite; Attid spiders.
Fungus—None recorded with certainty.
CONTROL: Sweeping grass and young cane with tarred frames; cutting grass near cane fields; crop rotation; introduction of parasites.

47. *Kolla* (?) sp. (not determined) subfamily Cicadellinæ).
COMMON NAME: Gray sugar-cane leafhopper.
DAMAGE: Quite common on young cane; no direct injury.
DISTRIBUTION: South coast and north-west coast.
FOOD PLANTS: Sugar cane and grasses.
ENEMIES: The same as those of preceding species.
CONTROL: None required.

48. *Jassid* (not yet determined) (subfamily Jassinæ).
COMMON NAME: Cane false-mottling leafhopper.
DAMAGE: Attacks leaves of young cane near tips, causing white streaks that resemble mottling disease.
DISTRIBUTION: North coast; possibly entire Island.
FOOD PLANTS: Sugar cane and grasses.
ENEMIES: No parasites yet observed.
CONTROL: Scarcely required.

49. *Balclutha* (*Gnathodus*) sp. (subfamily Jassinæ).
COMMON NAME: Cane seed-head leafhopper.
DAMAGE: Very abundant, in all stages, in seed tassels. Doubtless injures fertility of seed.
DISTRIBUTION: Entire Island.
FOOD PLANTS: Sugar cane and false Para grass, *Eriochloa subglabra;* occasionally other grasses.
ENEMIES: Animal—Same as those of Kolla.
Insect—A Dryinid, *Chalcogonatopus* sp., infests sometimes over 50 per cent of adults and nymphs; a Mymarid parasitizes large per cent of eggs; a Syrphid fly.
Plant—A fungus, undetermined, parasitizes all adults after attack by Dryinid.
CONTROL: Keep cut, in vicinity of cane fields, the "malojillo" (Eriochloa) upon whose seeds it feeds through the year.

50. *Bothriocera* sp. (probably new) (family Fulgoridæ).
COMMON NAME: Gray fulgorid-fly.
DAMAGE: Taken rarely feeding on cane; does no damage.
DISTRIBUTION: Entire Island; Vieques.
FOOD PLANTS: *Citrus* spp.; *Palicourea* spp.; *Anona* spp.; *Piper aduncum;* sugar cane (rarely); etc.
ENEMIES: No insect parasites recorded. A fungus, *Isaria saussurei* Cooke (det. J. A. Stevenson), attacks insect heavily on Palicourea and Piper.
CONTROL: None required.

51. *Oliaris* sp. (subfamily Cixiinæ).
 COMMON NAME: Cottontail plant-hopper.
 DAMAGE: Quite common on young cane, but no injury thus far observed.
 DISTRIBUTION: Entire Island.
 FOOD PLANTS: Feeds upon a great variety of plants and trees. Younger stages not known.
 ENEMIES: No insect or fungus parasites observed.
 CONTROL: Not necessary.

52. *Ormenis* sp. (subfamily Flatinæ).
 COMMON NAME: Moth-hopper.
 DAMAGE: Recorded by Van Dine[1] as "found breeding on cane leaves in one instance." Not observed on cane by the writer. Injury to cane inconsequent.
 DISTRIBUTION: Not recorded.
 FOOD PLANTS: Cannot be given, as species was not recorded.
 ENEMIES: Insect—A Hymenopterous parasite infests a large proportion of eggs of the two commoner species; a Syrphid larva feeds on eggs; a Dryinid rarely attacks nymphs.
 Fungus—*Metarrhizium anisopliæ*, form *minor* (det. J. A. Stevenson), has been found by writer infesting many adults of a common species on coffee.
 CONTROL: Not required on sugar cane.

53. Derbid (not yet determined) (subfamily Derbinæ).
 COMMON NAME: Veil-wing moth-hopper.
 DAMAGE: Sometimes very abundant at bases of mature cane. Injury not observed. Younger stages unknown.
 DISTRIBUTION: North coast.
 FOOD PLANTS: Sugar cane; a wild fern.
 ENEMIES: No insect or fungus enemies yet observed.
 CONTROL: None required.

54. *Stenocranus (Delphax) saccharivorus* Westw. (subfam. Delphacinæ).
 COMMON NAME: West Indian cane-fly.
 DAMAGE: All stages on foliage; feeding punctures give entrance to disease; honeydew causes black mold on foliage. Becomes extremely abundant on plants in confinement, but is scarce under field conditions.
 DISTRIBUTION: Porto Rico; Santo Domingo; Jamaica; southern U. S.; Barbados.
 FOOD PLANTS: Sugar cane; can breed on grasses, but rarely does.
 ENEMIES: Animal—Birds; tree frogs; lizards, especially *Anolis pulchellus*.
 Arthropod—Spiders; *Zelus rubidus; Franklinothrips vespiformis;* a Mymarid egg parasite; a

[1] In Jour. Econ. Ent., Vol. 6, No. 2, Apr. 1913, page 257.

Dryinid wasp; a Stylopid, *Stenocranophilus quadratus* Pierce, which is more beneficial than all other parasites combined.

Plant—A green fungus, not determined, rarely attacks adults.

CONTROL: Not required, due to lizards, parasites, and beating rains.

55. *Perkinsiella* sp. (undetermined) (subfamily Delphacinæ).

COMMON NAME: White-lined plant-hopper.

DAMAGE: Sometimes common on young cane, but does no noticeable damage; breeds on rice.

DISTRIBUTION: Entire Island.

FOOD PLANTS: Sugar cane, rice and grasses.

ENEMIES: No parasites yet recorded; a predacious Mirid bug.

CONTROL: None required.

56. *Aphis setariæ* Thos. (family Aphididæ).

COMMON NAME: The brown cane aphis.

DAMAGE. Infests stalk at the base of leaf sheaths; occurs uncommonly, on isolated canes.

DISTRIBUTION: Porto Rico; southern U. S., probably other Greater Antilles.

FOOD PLANTS: Sugar cane and grasses.

ENEMIES: Arthropod—Small spiders; Syrphid flies; several Coccinellid beetles; an internal parasite.

Fungus—Not recorded.

CONTROL: Too rare to require control. Thrives only when protected by the fire-ant, *Solenopsis geminata*, which builds earth shelters over colonies.

57. *Sipha flava* Forbes (family Aphididæ).

COMMON NAME: Yellow sugar-cane aphis

DAMAGE: Infests undersides of leaves, especially near tips of lower leaves; often becomes epidemic over considerable areas.

DISTRIBUTION Porto Rico; southern U. S.; probably other Greater Antilles.

FOOD PLANTS: Sugar cane and grasses.

ENEMIES: Animal—A lizard, *Anolis pulchellus*.

Arthropod—Small spiders; Coccinellids; Syrphid flies.

Fungus—*Agrostalagmus albus* reported by J. R. Johnston; never observed by writer.

CONTROL: No artificial control practicable, except in seedling plots, as parasites effect control promptly.

58. *Aleyrodes* sp. (apparently new) (family Aleyrodidæ).

COMMON NAME: Sugar-cane white-fly.

DAMAGE: Insignificant; attacks foliage, but appears to be rare.

DISTRIBUTION: Recorded only from Río Piedras by the writer.
FOOD PLANTS: None other than cane recorded.
ENEMIES: Parasitized by minute Hymenopteron.
CONTROL: None called for.

59. *Pseudococcus calceolariæ* Mask. (family Coccidæ).
COMMON NAME: Pink sugar-cane mealybug.
DAMAGE: Attacks roots, and the stalks at the nodes, stunting growth and inducing rot beneath leaf sheaths.
DISTRIBUTION: West Indies; Demerara; southern U. S.; California; Hawaii; Fiji; New Zealand.
FOOD PLANTS: Sugar cane; probably grasses; several other plants in other localities.
ENEMIES: Animal—Blackbirds; honey-creepers; rats and mice; lizards.
Arthropod—Earwigs; a predacious bug, near Triphleps; a Eulophid parasite; a Cecidomyid, *Karschomyia cocci* Felt; *Franklinothrips vespiformis;* a Coccinellid, *Cryptolæmus montrouzieri* (rarely).
Fungus—*Aspergillus flavus* and *Isaria* sp.
CONTROL: Treatment of cane seed; seed selection; use of self-stripping varieties, clean cultivation prior to planting; elimination of the fire-ant.

60. *Pseudococcus sacchari* Ckll. (family Coccidæ).
COMMON NAME: Gray sugar-cane mealybug.
DAMAGE: Practically the same as that of *P. calceolariæ,* but less common.
DISTRIBUTION: Porto Rico; Barbados; Trinidad; Mexico; California; Hawaii; Mauritius.
FOOD PLANTS: Sugar cane and grasses.
ENEMIES: The same as of preceding species.
CONTROL: Same as for pink mealybug.

61. *Pseudococcus* sp. (?) (apparently undescribed) (family Coccidæ).
COMMON NAME: Sugar-cane leaf mealybug.
DAMAGE: Attacks the leaves and leaf sheaths, especially of young cane. Has caused death of cane in confinement. Rarely observed in fields.
DISTRIBUTION: Not yet determined. Collected at Río Piedras by the writer.
FOOD PLANTS: Sugar cane and grasses.
ENEMIES: A Eulophid parasite and the Cecidomyid keep it in control.
CONTROL: None required.

62. *Pulvinaria iceryi* Guer. (det. by H. Morrison) (fam. Coccidæ).
COMMON NAME: Sugar-cane leaf scale.
DAMAGE: Attacks the leaves only; multiplies rapidly. Has killed young plants in confinement. Rare in the fields.
DISTRIBUTION: Entire Island; Mauritius; Reunion Island.

FOOD PLANTS: Sugar cane; grasses (rarely).
ENEMIES: Two species of Hymenopterous parasites; a Cecidomyid larva.
CONTROL: Held in check by parasites.

63. *Aclerda tokionis* Ckll. (det. by E. R. Sasscer) (fam. Coccidæ).
COMMON NAME: Larger sugar-cane stalk scale.
DAMAGE: Attacks the stalk on or near leaf sheaths. Rare.
DISTRIBUTION: Porto Rico; California; Japan. Recorded from Río Piedras and Guayama by Wolcott; not observed by writer.
FOOD PLANTS: Sugar cane (Porto Rico); bamboo (California and Japan).
ENEMIES: None recorded.
CONTROL: Not required.

64. *Targionia* (*Aspidiotus*) *succhari* Ckll. (det. E. R. Sasseer) (fam. Coccidæ).
COMMON NAME: Smaller sugar-cane stalk scale.
DAMAGE: Occurs frequently on stalk at nodes, but seldom abundantly.
DISTRIBUTION: Porto Rico; Jamaica; Barbados; Antigua; Java.
FOOD PLANTS: Sugar cane and grasses.
ENEMIES: A Hymenopterous parasite observed.
CONTROL: None required.

X. ARTHROPLEONA.

65. *Degeeria* sp. (?) (family Entomobryidæ).
COMMON NAME: Green springtail.
DAMAGE: Always present on undersides of foilage. Exact nature of damage not yet determined. Of doubtful economic importance.
DISTRIBUTION: Entire Island.
FOOD PLANTS: Sugar cane; banana: cotton; foliage of many plants and trees.
ENEMIES: No predacious insect enemies or parasites thus far observed.
CONTROL: Not considered to be necessary.

PREVIOUS PUBLICATIONS OF THE YEAR (1919-1920).

1. Annual Report of the Insular Experiment Station of the Department of Agri culture and Labor (1918-1919) of Porto Rico.
2. Journal of the Department of Agriculture. Vol. III, No. 3, The Mottling or Yellow-Stripe Disease of Sugar Cane, by John A. Stevenson.
3. Bulletin No. 19. The Resistence of Cane Varieties to Yellow-Stripe or the Mosaic Disease, by F. S. Earle.
4. Boletín No. 20. Insecticidas y Fungicidas, por I. A. Colón.
5. Boletín No. 21. Abonos (1918-1919), por F. A. López Domínguez.
6. Circular No. 17. Recomendaciones sobre el Cultivo de la Caña de Azúcar en Puerto Rico, por F. S. Earle.
7. Circular No. 18. El Exterminio de la Garrapata, por J. Bagué.
8. Bulletin No. 22. Eradication as a Means of Control in Sugar-Cane Mosaic or Yellow Stripe. The Year's Experience with this Method, by F. S. Earle.
9. Circular No. 19. La Mezcla de Abonos por el Agricultor, por F. A. López Domínguez.
14. Boletín No. 22. (La Edición Española.) La Extirpación del Mosaico de la Caña como Medio de Represión, por F. E. Earle.

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Vol. IV. JANUARY 1920. No. I.

THE JOURNAL

OF

THE DEPARTMENT OF AGRICULTURE

OF

PORTO RICO

SUGAR-CANE ROOT DISEASE INVESTIGATIONS

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SUGAR CANE ROOT DISEASE.

By F. S. EARLE.

For several years past attention in Porto Rico has been so centered on the damage caused by the sugar cane Mosaic or Yellow Stripe disease that there is danger of overlooking the even more serious losses caused every year by the so-called root disease. This trouble is always with us. There is not a cane field in the Island that is not more or less affected by it. It is the cause of the dying out of the cane in so many fields that necessitates such frequent replantings. If it were not for root disease we would be today cutting twenty or thirty ratoon crops from each planting of cane as was done in the early days of the cane industry on this Island, and is still being done on virgin lands in eastern Cuba and in Santo Domingo. The expense of these frequent replantings is by no means the only loss caused by root disease. It is safe to say that one form or another of the troubles known under this collective name is causing a loss of tonnage on every acre of cane now growing in Porto Rico. Few cane planters who really understand these facts will question the statement that this is by far the most serious problem that confronts the cane growers not only in Porto Rico but on old lands in all parts of the sugar-cane-growing world. Unfortunately the question is very complex and obscure. There is probably no other plant disease of equal importance about which so little is really known and concerning which such erroneous ideas have long passed current in plant-disease literature. Some chance discoveries recently made in connection with studies of the cane mosaic have thrown new

light on this most important subject and it seems opportune at this time to attempt a review of the entire problem.

SYMPTOMS.

The symptoms of root disease are sufficiently well known to most cane planters, yet they are not easy to accurately define. In the earlier stages they amount to little more than the slowing down of the normal growth of the cane. They are exactly the symptoms that would be expected when cane is planted on old worn-out lands without proper fertilizers. In other words, they are the preliminary symptoms of mal-nutrition, a lack of vigorous growth and a paling or slight yellowing of the leaves from the dark-green characteristic of cane in full vigor. These symptoms will be accentuated in dry weather, especially if this follows a period of excessive rains or in spots that have suffered from insufficient drainage. Bad drainage always intensifies the trouble from root disease. If drouth continues the leaves will begin to roll up during the middle of the day on the worse-affected spots. Later the lower leaves will die prematurely but will usually still hang to the stalk not falling like normally matured leaves. The old leaf sheaths near the ground will often be found to be matted together and cemented to the stalk by a conspicuous white, mould-like fungus mycelium. Still later the tips and margins of the remaining living leaves will be seared and brown and the general color becomes quite yellow. When rains come this diseased cane may regain its color and continue to make some growth but it never regains full vigor. As maturity of the crop approaches another phase of the trouble presents itself. The terminal bud on the more feeble stalks dies and this is followed by the rotting of the soft terminal tissues. This "top rot" is well known and is often incidentally referred to in cane-disease literature but it has never been satisfactorily explained. Of course, a top rot, especially in young cane when it is usually referred to as "dead heart" is often caused by injuries from the moth borer (Diatraea). A top rot of young overshaded suckers is also often caused by the fungus *Sclerotium Rolfsii* which is everywhere present in cane fields. The top rot referred to above, however, comes from neither of these sources, but in the opinion of the author is the direct result and culmination of the symptoms that have so long been known under the collective name of "root disease." Soon after the dying of the top the black pustules of the fungus *Melanconium* appear on the stalk, usually

beginning at the top of the stalk, following up the work of the top rot, but sometimes first appearing near borer injuries or on sun-scalded areas, and "rind disease" finishes the work of destruction by completely rotting the stalk unless harvesting quickly follows the appearance of top rot. The losses sometimes following from top rot and rind disease, which is now to be considered as the final manifestation of "root disease," are clearly shown by the notes (see page 18) on the variety experiment at Santa Rita when as early as December 10, before most of the mills had begun grinding, some of the more susceptible varieties were a total loss and where in the 90 plots of the standard Rayada the estimates showed an average of 29.4 per cent of top-rot stalks. Finally, after a severe case of root disease the cane stubble fails to ratoon, or at best ratoons very poorly. Such stools must be dug out and replanted if a ratoon crop is expected. This replanting of ratoons is carefully attended to in Porto Rico where it is part of the usual plantation routine. In Cuba it is frequently neglected with the consequence that great vacant areas soon appear at the worst diseased spots in the field. These are locally known as "sabanas" and they increase in area from year to year till the field is finally abandoned and plowed up.

The symptoms of root disease may then be summarized as follows:

1st. A slowing down of growth and lack of vigor accompanied by a more or less pronounced yellowing of the leaves.

2nd. The rolling up of the leaves at mid-day during periods of drouth.

3d. The premature dying of the lower leaves which remain hanging on the stalk and usually by the cementing of the leaf sheaths by a white fungus mycelium.

4th. A leaf burn causing the dying and browning of the tips and margins.

5th. Top rot, the dying of the terminal bud, followed by a soft stinking rot of the soft growing tissues.

6th. Rind disease, the appearance on the stalks of *Melanconium* and other fungi causing the rotting of the stalk.

7th. Failure to ratoon.

HISTORICAL.

During the first half of the last century the cane variety variously known as Caña Blanca, Bourbon or Otaheite, came to be grown very extensively in practically all of the tropical sugar-producing countries. It is a variety particularly well adapted to the rich

porous soil of newly cleared forest or so-called virgin lands, where it grows with great rapidity, giving a heavy tonnage of cane which yields a good percentage of sugar and which has unusually good milling qualities. Unfortunately, however, its root system is not adapted to the conditions found in old compacted soils. In one sugar-producing country after another this variety has given down, often with an apparent suddenness that has caused a serious crisis in the sugar industry, and it has been necessary to replace it by kinds better adapted to the compacted condition of old partially exhausted soils and more resistant to the complex troubles usually known under the name of Root Disease. Such a crisis occurred in the islands of Mauritius and Bourbon as early as 1846. In Porto Rico the outbreak in the Mayagüez district of the so-called epidemic of 1872 was clearly a manfestation of root disease. Similar crisis have occurred in Jamaica and other of the British West Indies. In Java the problem was complicated by the presence of the Sereh disease and the Yellow Stripe or Mosaic but the present custom of taking no ratoon crops but replanting the field annually has clearly largely come from the effect of root disease. In Cuba the abandonment of the Caña Blanca has been equally complete on all of the older cane lands, but as such a great area of virgin land was available for new plantings no sudden crisis resulted from a forced change of varieties. Fields of Caña Blanca (Otaheite) may still be found on the new lands of Eastern Cuba, but even here it is being rapidly replaced by the Crystalina In Porto Rico this variety which was once so universally planted has practically disappeared except in certain loamy irrigated soils of unusually good texture on the south coast and in limited areas of the richer hill lands of the interior. Even here it does not ratoon well but usually has to be replanted every year The entire question of varietal resistance to root disease is so important that it will be discussed under a separate heading.

Wakker in Java seems to have been the first investigator to assign a definite cause to sugar cane root disease (Arch. V Java Suikerindus, 1895). He found a small gill-fungus or mushroom growing on the trash at the base of diseased stalks which he considered to be the cause of the trouble. He named and described this fungus as *Marasmius sacchari* n. sp. His work has been accepted and followed by most subsequent investigators and to this day the terms root disease and Marasmius disease are used interchangeably in most publications on cane diseases.

During the years 1899–1902 Albert Howard was investigating sugar cane and other plant diseases for the Imperial Department of Agriculture of the West Indies with headquarters in Barbados. He seems to have been the first to identify our West Indian Root Disease as being identical with the trouble in Java. He found and identified *Marasmius sacchari* Wakker, and carried out a series of experiments that convinced him that it was the true cause of the trouble. In this he has been followed by Lewton-Brain, Bancroft, Tempany, Stockdale and other pathologists who have been connected with the Brithish West Indian Department of Agriculture.

During the years 1904–1906 root disease was investigated in Cuba by Cook and Horne. They found an abundant white mycelium involving the bases of the old leaf sheaths, but during this period found no fruiting bodies of the *Marasmius*. (Estac. Agro. de Cuba Bull. 7, 13, 1907.) They did find, however, the fructifications of another Hymenomycetus fungus, *Peniophora* sp., which they suggested as a possible cause for the disease. This was not supported by experimental evidence.

In Circular 18 Horne refers to this fungus again as probably being *Hypochnus sacchari*. In the second report of the Cuban Station (Inf. Ann. Esta. Agr. de Cuba 2: 81–. 1909, Horne again discusses root disease. He reports the finding of abundant fructifications of *Marasmius sacchari* Wakker in the fall of 1908 not only at the base of cane suffering from root disease but also on Johnson grass, Para grass and Guinea grass. He inclines to attribute the root disease to this fungus rather than to the *Peniophora* but again gives no experimental proofs.

In Hawaii in 1905 Lewton-Brain published as Bul. 2 of the Sugar Planters Experiment Station a paper entitled "Preliminary Notes on Root Disease in Hawaii." At this time he had not found fruiting bodies of Marasmius, but he considered the disease as identical with the West Indian root disease with which he was familiar in Barbados, The following year Marasmius fruiting bodies were found in connection with the root disease. These were named *Marasmius Sacchari var Hawaiiensis* by Cobb. (Sugar Station Bull. 5: 214, 1906). In this same publication, which is entitled "Fungus Maladies of the Sugar Cane," Cobb describes at great length a stink-horn fungus which he calls *Ithyphallus coralloides* n. sp. and to which he ascribes the principal roll as cause of the root disease The whole question was discussed and illustrated most elaborately but without one word

of proof to establish the causative relation of this fungus, which is one of the last that could reasonably be expected to be a parasite. Cobb's work has not been confirmed by other investigators, so this profusely illustrated paper may be dismissed as one of the curiosities of pathological literature.

In 1908 R. H. Fulton discussed root disease in Louisiana (Expt. Sta. Bull. 100). He ascribed it to a *Marasmius*, but to a different species which was determined as *M. plicatilis* Wakker.

In Porto Rico this disease has been extensively studied by both J. R. Johnston and J. A. Stevenson during the time of their connection with the Insular Experiment Station. In their joint paper on Sugar Cane Fungi and Diseases of Porto Rico (Jour. Dept. Agri. Porto Rico 1-(4) 1917) they enumerate and describe *Marasmius sacchari* Wakker, *Himantia Stellifera* Johnston sp. Nov., *Odontia saccharicola* Burt, *Odontia Sacchari* Burt and some other Hymenomycetous fungi as occurring at the base of cane stalks and apparently in connection with root disease, but they say (p. 189) "The exact status of root disease with respect to the parasitism of *Marasmius, Himantia, Odontia* or possibly other forms is uncertain, and while it is generally held that *Marasmius* at least is a true parasite, really definite evidence is lacking. Studies under controlled conditions must be carried out working with pure cultures of the fungi which has not yet been possible."

Stevenson in his more recent papers has used the term "Deterioration" to cover part of the symptoms that have been above described and has attempted to separate them from what he calls "Root Disease." This he considers as being caused by parasites, but as quoted above he does not consider it as proven that either *Marasmius* or the other conspicuous Hymenomycetes connected with the disease are its true cause.

In the *Hawaiian Planters Record* for July, 1919, Mr. H. L. Lyon has published a paper entitled "A Preliminary Report of the Root Rot Organism." In this paper he describes and figures an organism which he does not name but [illegible] to the *Chytridineæ* which he considers "the primary cause of the Lahaina disease (of cane) and pineapple wilt throughout these islands and perhaps in other tropical countries as well." The vegetative stage of this organism consists of small naked plasmodia, either rounded or irregular and elongated, which occur two or more together in the same root cell. These plasmodia are believed to fuse and to then form either a sporangium or

a resting spore since these are uniformly found only one in each host cell. The sporangia soon give rise to motile zoospores. The resting spores are thick-walled globular bodies. They were kept under observation for several months but it had been impossible to induce them to germinate. They occur in the soft tissues of the root often near the growing point. When the presence of this organism causes the death of a root it is soon completely destroyed by secondary organisms.

The above hasty review of the literature of Root Disease is in no sense intended as a complete bibliography, but it is believed that it covers all of the different views that have been published regarding this disease, or as perhaps it had better be called this complex of diseases. It should be added that white grubs (*Lachnosternum*) and other root-eating insects often produce somewhat similar symptoms, the results to the cane being much the same whether the roots are killed by fungi or are eaten off by insects. A certain amount of such root insect injury is doubtless often included under the general name of root disease. Mealy bugs too (*Pseudococcus*) are very abundant in most cane fields and aid in creating that state of debility that accompanies the first stage of root disease.

The technical studies on certain organisms connected with root disease that are reported on another page of this publication by Mr. Matz represent a distinct advance in our knowledge of this most important complex of diseases. When Mr. Matz came to the Insular Station a little over a year ago the present writer took every occasion to impress on him the overshadowing importance of root disease as a sugar-cane problem and pointed out the entirely inadequate treatment of the question in plant-disease literature. He personally collected and brought to the laboratory much of the material on which these studies are based and has watched every step of the investigation with closest interest. He therefore feels competent to discuss the results and to express a decided opinion on the following points:

1st. *Marasmius* is at best a very feeble parasite. It may overrun new healthy roots or other organs without killing them. The same may be said of the so-called "stellate fungus" and of the other Hymenomycetes that form a conspicuous white mycelium on cane trash and at the base of cane stalks.

2nd. The killing of the roots which is so marked a feature in "root disease" is usually caused by various species of *Rhizoctonia* and sometimes by a species of *Pythium*. These are the well-known

causes of the damping off of seedlings and cause heavy losses in tobacco and vegetable seed beds but they have not before been connected with a disease of cane.[1] This seems most remarkable in view of the fact that some one of these species has been isolated from almost every diseased cane root from which cultures have been made and that in every case they have promptly killed every cane root on which pure cultures have been planted. Nothing could be more convincing than that these heretofore unsuspected species and not *Marasmius* and its allies are the true root-killing agents. We can only conclude that previous workers have done little in the way of making cultures from dying cane roots or they could have hardly failed to have detected these fungi which are so easily isolated and grown in artificial cultures.

This very satisfactorily clears up what may be considered as root disease proper, viz., the actual killing of the roots. The conditions under which this occurs and its relations to cultural practices will be discussed in another paragraph. The above organisms are all facultative parasites, and as such may be controlled at least to some extent by cultural methods.

3d. The finding of a strict parasite within the vascular bundles of cane suffering from root disease was an entirely accidental and unexpected result from some anatomical studies of cane tissues made in connection with the investigation of the sugar-cane Mosaic (see Journ. Dept. of Agr. Porto Rico, Vol. III, 4, Oct. 1919). At first it

[1] Since the above was written Hawaii Federal Station Press Bulletin 54 (issued December 9, 1919) has been received. It is by C. W. Carpenter and is entitled "Preliminary Report on Root Rot in Hawaii." In this interesting paper Mr. Carpenter attributes the root rot of cane, Taro, bananas and rice and the wilt of pineapples in Hawaii all to the action of a species of Pythium which he considers as probably P. DeBaryanum. In discussing Lyon's paper he expresses the opinion that the resting spores found by the latter in cane and pineapple roots are in reality the oospoers of this *Pythium*. Oospores have been produced abundantly in Mr. Matz's cultures here of *Pythium* from diseased cane roots. They certainly strikingly resemble the bodies figured by Lyon but they are always accompanied by a conspicuous mycelium. Furthermore, they germinate readily. These facts make us doubtful whether or not Carpenter and Lyon are discussing two distinct organisms. Mr. Carpenter's paper, however, corroborates Mr. Matz's conclusion that *Pythium* is one of the active agents in killing cane roots.

A review of additional literature not accessible when the above note and paragraph was written shows that Pythium has long been known to attack cane roots. In discussing the Sereh disease in Java. Dr. M. Treub in 1885 (Med. Slands Plant, Buitenzorg 2: 80–85, 1885) refers at some length to *Pythium* on the roots as a possible cause. In 1896 Dr. J. H. Wakker in a paper entitled De Schimmels in de Wortels van Het Suikerriet (Med. Proefs. Oost–Java (n. series) [illegible],) gives a fine plate and a long discussion of *Pythium* as the cause of the killing of cane roots. The more conspicuous *Marasmius* seems, however, to have attracted his attention more strongly as it has that of most subsequent investigators and no subsequent mention of *Pythium* as a cane fungus has been found in the literature until that of Carpenter as mentioned above.

was thought that this organism might have some connection with the mosaic disease since it was originally discovered in the tissues of an advanced case of mosaic. Later, however, it was found not once, but very many times and from widely different localities in cane that was suffering from root disease but that was absolutely free from mosaic. The evidence is conclusive that this organism is connected with the former disease but not with the latter.

Its life history has not been fully worked out. The vegetative stage consists of a yellow plasmodium which occupies the larger vessels of the vascular bundles often completely filling them for considerable distances. Infected bundles may be easily detected with a hand lense, or even with the naked eye, in either cross or longitudinal cuts on account of their peculiar orange-yellow color. This is quite distinct from the reddening of the bundles that so often accompanies any mechanical injury. These plugged bundles are more abundant near the base of the cane, especially in the part which develops below ground, but they have also been found in the roots, and they can often be traced for long distances up into the cane, occasionally, in mature cane, almost to the terminal bud.

This plasma is multi-nucleate. After a time each nucleus surrounds itself with a rounded mass of the cytoplasm and begins to divide first into two, then into four, and finally into a mass of dense granules. At the same time a cell wall is being formed and the result is a globose, thick-walled resting spore. The cell wall is smooth and hyaline, but the content is so densely granular that the spore is dark and opaque. They are produced in great numbers and remain imbedded in the cytoplasm, which finally becomes somewhat hardened and gum-like. So far these spores have resisted all attempts to germinate them. The remainder of the life-history can therefore only be conjectured. It seems most probable that when these infected canes and cane stubbles rot in the soil these resting spores are liberated and in their own good time germinate probably by the formation of motile zoospores. These probably find their way into new cane roots and thus start the infection of other canes. It is evident also that when infected canes are cut up and used as seed for new plantings that the disease could be propagated in the new field by the continued growth of the original plasma.

If the above hypothesis is correct and these resting spores do break up into motile zoospores the organism would have to be classed among the *Myxomycetes* or Slime moulds. The only recognized

genus to which it could be referred would be *Plasmodiophora*. It differs from the known species of this genus in the much larger size of the spores and in the fact that it causes no enlargement or distortion of the cells of the host. It seems best to withhold a final opinion as to its name and systematic position until its life history has been more fully determined.

The resting spores of this organism are so very similar to those figured and described by Lyon for the supposed Chytridiaceous fungus discovered by him as a cause of root disease in the Hawaiian Island that it was at first assumed that we had found the same organism. This, however, can hardly be the case. We have found nothing resembling the sporangia and definitely formed plasmodia which he figures. The resting spores of his organism occur singly in the parenchyma cells of the young roots and the epispore is irregularly thickened. Our organism is in the vascular bundles, not the parenchyma. The plasmodium is indefinitely continuous, often for a distance of many centimeters. The numerous resting spores have a smooth cell wall of equal thickness throughout. It seems clear that this organism belongs in the Slime moulds and not in the *Chytridiaceæ*. It is, however, remarkable that two such similar but distinct organisms are causing serious damage to sugar cane in different parts of the world and that both had so long escaped detection.[1]

It is not possible as yet to express a fixed opinion as to the damage being done by this vascular bundle parasite, nor as to its exact roll in the complex we are considering under the name of "root disease." It is not probable that it is an active agent in the actual killing of roots. In fact, it is quite certain that this is not the case. The actual root killers are facultative parasites and as such their action is largely inhibited when the cane is in full vigor. The bundles fungus is doubtless one of the many contributing causes to lack of vigor and thus may be indirectly responsible for loss of roots. Whether its action is merely mechanical, simply resulting in the plugging of the bundles it occupies, or whether it may secrete injurious substances we do not know. If the former, an occasional plugged bundle will cause little or no harm, but if many of the bundles are invaded the result would inevitably be the rolling up and withering of the leaves and finally the death of the terminal bud. It seems probable, therefore, that this bundle fungus is core-

[1] See note on page 10.

lated with the baffling condition known as "top rot" rather than with "root rot" proper.

Whatever the damage it may be doing it is widely scattered in Porto Rico, having been found in every cane-growing district where a search has been made for it. It is interesting to note that the old Caña Blanca (Otaheite or Lahaina) is particularly susceptible to it. It was found to be very abundant in the few stalks of this kind that have survived in the experimental plots at the Mayagüez Station where it had been interplanted among the other kinds as a check and where it practically all failed to ratoon at the end of the first year. This particular field, by the way, is said to be the one where the famous epidemic of 1872 first made its appearance. This may be only a coincidence, but it at least suggests this as one of the factors in that outbreak.

The habit of growth of this fungus makes it certain that it has been widely transported in seed cane. It therefore probably has a wide distribution in all cane-growing countries. It should certainly be carefully searched for by all investigators. Its presence indicates the great unwisdom of taking seed cane from old, neglected fields where it is quite certain to be more abundant than in new plantings. It also probably explains the better results usually obtained from planting "top seed" since it is comparatively rare for this organism to reach the top joints of the cane. Where the entire cane is used for planting the butt cut should certainly be rejected since this is much more likely to be infected.

4th. The above discussion throws light on the much-discussed problem of "top rot."[1] It seems entirely probable that this bundle inhabiting, *Plasmodiophora*-like organism is the original cause of "top rot," aided, of course, by the root-killing fungi and the other factors of "root disease" that unite to lower the vitality of the cane. The writer is well aware that no positive proof has been given as to the casual agency of the bundle fungus in producing "top rot." He only wishes to point out the strong probability that this is the fact.

In cases of "top rot" the withering leaves of the terminal bud spindle soon show numerous, scattered, minute black specks which

[1] Since the above was written the Gumming disease or Sugar Cane Gomosis has been found in Porto Rico. (See J. Mata, Insular Station Circ. 20, 1920.) This also causes a top rot, but such cases can be distinguished by the flow of gum from cut surfaces of the stalks.

under the microscope prove to be the fruiting bodies of some fungus. As noted by Stevenson in his discussion of "wither tip," (Jour. Dept. Agr. Porto Rico 1:207.) This usually is found to be either *Sphærella sacchari* Speg. or *Periconia sacchari* Johnston.

At about the time that these fungus specks become visible a stinking bacterial rot occurs in the soft tissue about the growing point. This rot only involves the soft tissues. Sometimes the disease is checked at this point, the rotted top falling away while the joints below remain sound, the lateral buds soon pushing into new shoots. More often, however, the black pustules of "rind disease" appear on the joints below the rotten tip and this soon completes the destruction of the stalk.

Clearly these bacteria and fungi so uniformly associated with "top rot" are saprophytes and agents of decay but it is very probable that they are also facultative parasites and are able to attack cane tops that have been weakened by other causes without waiting for death to occur. This point needs further study. Whether the fungi or the bacteria or both are real killing agents has not been determined. In any event it seems certain that they cannot attack cane that is in full vigor and health.

Many references occur in the literature to a supposed bacterial top rot of cane but no proof exists that there is a specific disease of this nature apart from the fact that bacteria are always present in the soft, rotting tissue.[1] The whole subject needs much careful investigation. The above discussion is intended to be suggestive rather than final.

5th. In the preceeding paragraph the statement is made that "rind disease" usually sets in to complete the work of destruction caused by "top rot," the predisposing causes for this last condition being here held to be "root rot" and the presence of the bundle inhabiting *Plasmodiophora*-like organism. The "rind disease" here referred to is assumed to be caused by *Melanconium sacchari* Mass. The discussion of this fungus in plant-disease literature has been involved with many needless and really inexcusable errors. It seems clear that this fungus has nothing to do with either *Trichosphæria*, *Thielavioposis*, *Diplodia* or *Colletotrichum*, although eminent mycolo-

[1] Mr. Noel Deerr has informed the writer that a contagious bacterial top rot exists in Demerara but his studies regarding it have not been published.

gists have frequently expressed a contrary opinion. This is a very common saprophyte, growing everywhere on dead cane trash. It is not an active parasite but can attack enfeebled cane tissue before it is quite dead. It often follows borer injuries but in these cases seldom is able to pass the nodes being confined to the one injured joint. Where canes have been so weakened by "root disease" that they have fallen a victim to "top rot" the vitality is so lowered that the *Melanconium* is usually able to quickly invade and destroy the entire cane.

Varieties differ greatly in their power of resisting "rind disease," the Otaheite or Caña Blanca being particularly susceptible. This question will be further discussed in a subsequent paragraph.

To what extent the "red rot" caused by *Colletotrichum falcatum* Went. has been confused with "rind disease" it is not easy to determine, especially since they often occur together, in which case this fungus is likely to be overlooked, being obscured by the more conspicuous *Melanconium*. Apparently, *Colletotrichum* is not as injurious here as in many other cane-growing countries. It is, however, known to occur and Stevenson reports the presence of three other unnamed forms of this genus as occurring on sugar cane in Porto Rico. Their distribution and economic importance should be given careful study.

6th. *Failure to ratoon.*—Cane suffering from the advanced stages of "root disease" (including "top rot" and "rind disease") seldom ratoons well and in many cases fails entirely, thus causing the necessity for the early abandonment of the planting. This represents an even greater financial loss than the yearly shortage in tonnage. It may be considered as the final culmination of this series of disasters. It completes the picture of the complex of trouble as we now understand them that are grouped under the comprehensive name of "Sugar Cane Root Disease."

THE RESISTANCE OF CANE VARIETIES TO ROOT DISEASE.

Ever since root disease was first recognized it has been noted that different varieties were very differently affected by it, some being very susceptable while others were comparatively resistant. The old favorite Otaheite, Caña Blanca, Bourbon or Lahaina as it has been variously called, has always suffered more severely than any other

kind in general cultivation. It seems to be particularly susceptible to all phases of this complex of maladies. Its root system is delicate, and while well adapted to rich porous lands that are well supplied with humus it quickly succumbs to the attacks of *Rhizoctonia*, *Pythium* and other root-killing fungi when the soil becomes old and compacted. It was never a strong ratooner and on unfavorable soils it often completely fails to ratoon even after the first cutting. In addition it proves to be a favored host for the vascular bundle fungus that has been above described and the stalks are particularly susceptible to the *Colletotrichum* red rot and to the *Melanconium* rind disease. One or another of these troubles or a combination of them has caused its failure and abandonment in practically all cane-growing countries. The opinion has been widely expressed that this variety was degenerating. The facts, however, do not support this idea. Where all conditions are favorable it grows with its old-time vigor. It is simply a susceptible variety only adapted to a narrow range of conditions. It is the old, long-cultivated soils that have deteriorated and not the Otaheite cane.

It was the failure, often the sudden and disastrous failure, of this old favorite that first forced serious attention on other kinds and that has lead in so many countries to the extensive production of new seedling varieties. Many of these new kinds have come to be extensively planted. In fact, the sugar industry of many regions is now based almost entirely on some of these new kinds. Their success has been almost entirely due to their resistance to root disease. It is a remarkable fact that among the multitude of new kinds produced and tested so few have surpassed or even equaled the old standard varieties in sucrose content and purity. New kinds are everywhere pushing out the old standard kinds, Otaheite, Crystalina, Rayada and Morada (purple), not because they are richer, better milling canes but because they are more resistant to root disease and so give better tonnage for a longer series of years.

Much attention has been given to this subject in the British West Indies and the reports from the different agricultural stations there are filled with notes on the resistance or susceptibility to the root disease of different varieties in different localities and different seasons. In the publications of the Porto Rican Stations casual mention can be found regarding the resistance of various kinds but no comprehensive study of the question seems to have been made under

our local conditions. A coöperative planting of 171 varieties made at Santa Rita, Guánica, in the irrigated district on the south side of the Island, for the purpose of testing their resistance or susceptibility to the Sugar Cane Mosaic, has been reported on in Bulletin 19 of the Insular Station. At the time of the last inspection reported in this bulletin, August 10, 1919, it was evident that some kinds were not doing as well as others aside from the effects of the mosaic infection.

It was suspected then that root disease was also at work, but as yet it was only in the preliminary stages, no signs of "top rot" or "rind disease" having appeared. Subsequent visits showed that the combined effect of the root disease and the mosaic were going to result in heavy losses from "top rot." It is not considered that the mosaic was in any sense a primary cause of this top rot. Its presence was simply one more factor in lowering vitality of the cane. Some white grubs (*Lachnosterna*) were also present and helped to secure the total injury which ended in disaster for most of the kinds in these plots.

Rhizoctonia had been isolated from cane roots from this field early in the season and it was found that many of the canes were infected by the vascular bundle parasite. On December 10, 1919, about the time when Central Guánica is usually actively grinding the *gran cultura* plantings, a final inspection was made and the per cent of "top-rot" stalks in each row was estimated. It will be remembered that every third row in these plots was planted with Rayada seed infected with Mosaic in order to insure the equal exposure of the other kinds to that disease. There were 90 of these Rayada plots. The per cent of "top rot" was estimated in each of these. In 8 of them it was placed as low as 5 per cent. One was a complete loss, 100 per cent. The average of the estimated loss on the 90 plots was 29.4 per cent, so that figure is given in the following table. Twenty-six kinds had been cut for seed and had ratooned, so notes could only be taken on the condition of the ratoons. It is to be presumed that most of these kinds would have shown good resistance to the root disease had they been standing. Most of the top-rotted canes had developed rind disease and were fast becoming a total loss. The average condition of the field was deplorable, though it was planted on very fine land and had had the best of irrigation and cultivation.

Table Showing Resistance and Susceptibility to Root Disease in the Santa Rita Variety Experiment.

Name of variety.	Estimated per cent top rot.	General conditions.
Cavengerie	Cut for seed	Stand and condition ratoons only fair.
Crystalina	20 per cent	Poor.
Fortuna seedling	4 per cent	Very good.
Karandali (Calancana)	Vacant	
Kavangire	No top rot	Decidedly best condition and heaviest tonnage.
Otaheite	70 per cent	Very poor.
Rayada	29.4 per cent	Average poor.
S. Seedling (= B-3412)	5 per cent	Very good.
White Transparent (= Crystalina).	20 per cent	Fair.
Yellow Caledonia	Mostly dead from Mosaic.	Two remaining stools very good.

BARBADOS SEEDLINGS.

Name of variety.	Estimated per cent top rot.	General conditions.
B-109	Cut for seed	Stand of ratoons fair, condition good.
B-208	10 per cent	Fairly good.
B-376	20 per cent	Fair.
B-1355	10 per cent	Good.
B-3390	Vacant	
B-3412	10 per cent	Fair.
B-3578	5 per cent	Very good.
B-3669	Mostly dead	Poor.
B-3859	Cut for seed	Ratoons only fair.
B-3922	5 per cent	Fair.
B-4028	Vacant	
B-4596	No top rot	Very good.
B-6048	No top rot	Only two hills fair.
B-6292	20 per cent	Fairly good.
B-6450	4 per cent	Very good.
B-6536	15 per cent	Fair.
B-7168	Vacant	

DEMERARA SEEDLINGS.

Name of variety.	Estimated per cent top rot.	General conditions.
D-109	20 per cent	Fair.
D-117	15 per cent	Fair.
D-357	30 per cent	Fair.
D-433	Cut for seed	Ratoons only fair.
D-504	Vacant	

Table Showing Resistance and Susceptibility to Root Disease in the Santa Rita Variety Experiment—Continued.

CENTRAL FAJARDO SEEDLINGS.

Name of variety	Estimated per cent top rot.	General conditions.
F. C. 79	5 per cent	Very good.
F. C. 84	5 per cent	Good.
F. C. 86	4 per cent	Good.
F. C. 88	10 per cent	Fair.
F. C. 90	5 per cent	Good.
F. C. 95	Cut for seed	Ratoons, stand fair, condidition good.
F. C. 97	10 per cent	Good.
F. C. 98	Only two stools living	Poor.
F. C. 99	60 per cent	Very poor.
F. C. 101	5 per cent	Good.
F. C. 104	Cut for seed	Ratoons only fair.
F. C. 103	5 per cent	Good.
F. C. 110	30 per cent	Very poor.
F. C. 114	40 per cent	Poor.
F. C. 129	5 per cent	Good.
F. C. 131	5 per cent	Good.
F. C. 133	Cut for seed	Ratoons good stand and condition.
F. C. 136	30 per cent	Poor.
F. C. 137	Only one stool living	Fair.
F. C. 140	5 per cent	Fair.
F C. 148	40 per cent	Poor.
F. C. 155	Only two stools living	Fair.
F. C. 158	5 per cent	Good.
F. C. 163	10 per cent	Good.
F. C. 170		Fair.
F. C. 171	30 per cent	Fair.
F. C. 174	40 per cent	Poor.
F. C. 178	Cut for seed	Ratoons only fair.
F. C. 188	2 per cent	Good.
F. C. 193	2 per cent	Very good.
F. C. 194	5 per cent	Good.
F. C. 197		Fair.
F. C. 199	Cut for seed	Ratoons good stand and condition.
F. C. 200	100 per cent	Complete loss.
F. C. 202	Cut for seed	Ratoons only fair.
F. C. 204	Cut for seed	Ratoons only fair.
F. C. 205	Only one stool	Fair.
F. C. 214	No top rot	Very good.
F. C. 225	10 per cent	Fair.
F. C. 226	5 per cent	Fair.

Table Showing Resistance and Susceptibility to Root Disease in the Santa Rita Variety Experiment—Continued.

CENTRAL FAJARDO SEEDLINGS—Continued.

Name of variety.	Estimated per cent top rot.	General conditions.
F. C. 230	10 per cent	Fair.
F. C. 231	40 per cent	Poor.
F. C. 233	50 per cent	Poor.
F. C. 239	Cut for seed	Ratoons only fair.
F. C. 246	10 per cent	Fair.
F. C. 249		Fair.
F. C. 260	50 per cent	Poor.
F. C. 277	Cut for seed	Ratoons good stand and condition.
F. C. 279	20 per cent	Poor.
F. C. 280	10 per cent	Fair.
F. C. 281	5 per cent	Good.
F. C. 292	50 per cent	Poor.
F. C. 299	30 per cent	Poor.
F. C. 303	10 per cent	Fair.
F. C. 305	Only one stool living	Fair.
F. C. 306	40 per cent	Poor.
F. C. 308	5 per cent	Good.
F. C. 312	5 per cent	Very good.
F. C. 317	5 per cent	Good.
F. C. 322	Cut for seed	Ratoons good stand and condition.

GUANICA CENTRAL SEEDLINGS

Name of variety.	Estimated per cent top rot.	General conditions.
G. C. 47	4 per cent	Good.
G. C. 127	No top rot	Very good.
G. C. 149	2 per cent	Very good.
G. C. 425	10 per cent	Good.
G. C. 426	5 per cent	Good.
G. C. 434	5 per cent	Good.
G. C. 469	2 per cent	Good.
G. C. 490	20 per cent	Fair.
G. C. 493	4 per cent	Good.
G. C. 606	Cut for seed	Ratoons poor stand, fairly good condition.
G. C. 629	60 per cent	Very poor.
G. C. 698	20 per cent	Fair.
G. C. 701	Cut for seed	Ratoons full stand, fair condition.
G. C. 888	2 per cent	Very good.

Table Showing Resistance and Susceptibility to Root Disease in the Santa Rita Variety Experiment—Continued.

GUANICA CENTRAL SEEDLINGS—Continued.

Name of variety.	Estimated per cent top rot.	General conditions.
G. C. 908	15 per cent	Good.
G. C. 928	10 per cent	Good.
G. C. 949	20 per cent	Fair.
G. C. 1060	4 per cent	Good.
G. C. 1180	30 per cent	Fair.
G. C. 1246	10 per cent	Good.
G. C. 1254	2 per cent	Very good.
G. C. 1313	Cut for seed	Ratoons good stand, fair condition.
G. G. 1332	10 per cent	Good.
G. C. 1346	10 per cent	Fair.
G. C. 1358	30 per cent	Poor.
G. C. 1441	10 per cent	Good.
G. C. 1454	100 per cent	Complete loss.
G. C. 1480	10 per cent	Good.
G. C. 1482	95 per cent	Very poor.
G. C. 1484	10 per cent	Fair.
G. C. 1485	20 per cent	Fair.
G. C. 1486	Cut for seed	Ratoons good stand and condition.
G. C. 1486 (2nd lot)	4 per cent	Very good.
G. C. 1487	50 per cent	Poor.
G. C. 1489	50 per cent	Very poor.
G. C. 1495	20 per cent	Fair.
G. C. 1504	Cut for seed	Ratoons poor stand, only fair condition.
G. C. 1508	30 per cent	Poor.
G. C. 1509	10 per cent	Fair.
G. C. 1511	20 per cent	Poor.
G. C. 1513	Cut for seed	Ratoons good stand, fair condition.
G. C. 1515	10 per cent	Good.
G. C. 1517	5 per cent	Good.
G. C. 1518	Cut for seed	Ratoons good stand and condition.
G. C. 1519	20 per cent	Poor.
G. C. 1521	Cut for seed	Ratoons only fair stand and condition.
G. C. 1522	2 per cent	Very good.
G. C. 1523	60 per cent	Very poor.
G. C. 1524	50 per cent	Very poor.
G. C. 1526	50 per cent	Very poor.
G. C. 1527	4 per cent	Good.

Table Showing Resistance and Susceptibility to Root Disease in the Santa Rita Variety Experiment—Continued.

GUANICA CENTRAL SEEDLINGS—Continued.

Name of variety	Estimated per cent top rot.	General conditions.
G. C. 1530	50 per cent	Very poor.
G. C. 1531	95 per cent	Lost.
G. C. 1533	50 per cent	Poor.
G. C. 1534	50 per cent	Very poor.
G. C. 1535	10 per cent	Poor.
G. C. 1536	80 per cent	Very poor.
G. C. 1537	10 per cent	Poor.
G. C 1538	3 per cent	Good.
G C. 1539	No top rot	Very good.
G. C. 1540	1 per cent	Good.
G. C. 1541	30 per cent	Poor
G. C. 1542	100 per cent	Complete loss.
G. C. 1544	4 per cent	Good.
G. C. 1545	Cut for seed	Ratoons full stand, fair condition.
G C 1546	30 per cent	Poor.
G. C. 1547	50 per cent	Very poor.
G. C. 1548	4 per cent	Good.

JAVA SEEDLINGS, P. O J

Name of variety	Estimated per cent top rot	General conditions
Java 36 P. O. J.	Cut for seed	Ratoons stand perfect, condition best.
Java 228 P. O. J.	20 per cent	Very good.
Java 234 P. O. J.	Cut for seed	Ratoons stand perfect, condition best.

PORTO RICO SEEDLINGS.

Name of variety	Estimated per cent top rot	General conditions.
P. R. 68	20 per cent	Poor.
P. R. 208	20 per cent	Fair.
P. R. 209	50 per cent	Poor.
P. R. 210	10 per cent	Good.
P. R. 226	10 per cent	Fair.
P. R. 260	Cut for seed	Ratoons only fair stand and condition.
P. R. 270	50 per cent	Poor.
P. R. 292	5 per cent	Very good.
P. R. 317	5 per cent	Fair.
P. R. 318	10 per cent	Good.

In discussing the above table it must be borne in mind that practically all of this cane, excepting only the Kavangire, was heavily infected with Mosaic, which by lowering its vitality had greatly contributed to this disastrous result. It is considered, however, that this has only accentuated the effects of the root disease and has brought out with unusual clearness the resistance or susceptibility of these different kinds. The 26 kinds cut for seed in September were those considered most promising by the Agricultural Staff of Guánica. Had they remained standing they would doubtless all appear in the resistant lists. It is known from two seasons' observations at the Mayagüez Experiment Station that Java 36 and Java 234 are almost equally as resistant to root disease as the Kavangire. These three clearly make a class apart in their almost complete immunity to root disease and in their great ratooning power. It will be noted that the Kavangire is of straight North Indian blood while the other two are hybrids with another North Indian cane, the Chunnee, as staminate parent. The so-called Egyptian cane (see Bulletin 19, p. 15) is probably Java 105 P. O. J., and if so is another of this set of hybrids. It promises to be equally resistant with the others but unfortunately it was not included in this experiment: we therefore have—

LIST 1.—*Varieties practically immune to root disease.*

Kavangire	Java 105 P. O. J. "Egyptian".
Java 36 P. O. J.	Java 234 P. O. J.

Of the remaining broad-leaved canes there are only four which showed no cases of top rot.

LIST 2.—*Highly resistant varieties, showing no top rot.*

B. 4596	G. C. 127
F. C. 214	G. C. 1539

LIST 3.—*Resistant varieties showing general good conditions and only 2 per cent to 5 per cent of the top rot.*

B. 3578	G. C. 1254
B. 6450	G. C. 1486
F. C. 79	G. C. 1491
F. C. 193	G. C. 1522
F. C. 312	Java 228 P. O. J.
Fortuna Seedling	P. R. 292
G. C. 888	Sealey Seedling

The kinds cut for seed and which would probably have fallen in either 2 or 3 follow, as—

LIST 4.—*Varieties cut for seed, probably resistant.*

B-109	F. C. 277 * *
B-3859	F. C. 322 * *
Cavangerie	G. C. 606
D-433	G. C. 701 *
F. C. 95	G. C. 1313 *
F. C. 104	G. C. 1486 * *
F. C. 133 * *	G. C. 1504
F. C. 178	G. C. 1513 *
F. C. 199 * *	G. C. 1518 * *
F. C. 202	G. C. 1521
F. C. 204	G. C. 1545 *
F. C. 239	P. R. 260

Those marked with an "*" in the above list show a complete stand of ratoons, those with "* *" have a complete stand and show superior vigor.

These lists include the only kinds that would have made a satisfactory commercial crop under the trying conditions of this experiment The others grade all the way from a 15 per cent or 20 per cent reduction in crop to a complete loss. But for its extreme susceptibility to Mosaic disease Yellow Caledonia would assuredly have been found in one of these lists since it has very considerable resistance to root disease. This table should have a great practical interest for every cane grower in Porto Rico since it illustrates so forcibly the supreme importance of selecting the proper variety for planting in order to avoid very serious possible losses. It is seldom that circumstances combine to produce such striking results as were given by this experiment, but on the other hand there can be no question but that root disease is exacting a heavy toll in practically every cane field in the Island.

One of the most impressive lessons from this experiment is the outstanding superiority in resistance of the canes of North Indian parentage. Kobus in Java seems to be the only cane breeder who has realized and taken advantage of this most important fact. The continued indiscriminate breeding of new seedlings of the ordinary broad-leaved tropical type of canes does not seem to be leading to any advantage. Crossing a vigorous North Indian cane like Kavangire or the Crystalina which represents the best of the rich-juiced, broad-leaved tropical canes should lead to much more favorable re-

sults. Such crosses could be easily made by simply planting the two kinds in adjoining rows since the Crystalina is usually sterile to its own pollen. The present writer is only temporarily in Porto Rico. It is unlikely that he will ever have the opportunity to undertake cane breeding, but he strongly urges this cross on the attention of those who do continue in this work.

REMEDIAL MEASURES AGAINST ROOT DISEASE.

It is clear from the discussion under the last heading that the planting of resistant varieties is likely to prove the most effective remedial measure. It is also clear that the varieties descended from the slender, narrow-leaved North Indian canes show greater resistance to this complex of troubles than the stouter, sweeter, broad-leaved tropical kinds, though many of these last show very satisfactory resistance.

Making a complete change in variety is often difficult and it may be costly. It always takes considerable time. It must be admitted, too, that none of the resistant kinds so far tested are really equal to Crystalina and Rayada as desirable milling canes. It is of great practical importance, therefore, to consider what other remedial measures are possible and how satisfactory they have proven in actual practice.

It must be remembered that so far as we know all of the organisms that cause injuries in connection with this disease, with the one exception of the vascular bundle fungus, are facultative parasites. That is, they cannot attack tissues that are in vigorous growth but only those that have become weakened from some cause or that have reached such a state of over maturity or senility that the vital processes are lowered. All of the root killers and all of the organisms found in the dead tops and in rind disease and red rot belong in this category. It is a fact of general knowledge that diseases caused by facultative parasites are as a rule best controlled by improved cultural methods. Cane-root disease is no exception. The more abundant use of properly balanced fertilizers; careful attention to drainage where needed as well as the avoidance of unnecessary ditching; most important of all in Porto Rico, sufficient cultivation with implements to keep the soil open and porous and to prevent crusting; and the use of irrigation when soil or climate conditions demand it will go far to prevent the enormous losses now caused by this complex of diseases. On the contrary, the factors

that contribute most largely to these losses are lack of fertility, lack of suitable drainage, hard, compacted, unworked soils, severe drouths, and injuries from insects or other diseases such as white grub, mealy bug or Mosaic. The author's experience in Porto Rico is limited, but he has observed innumerable instances in Cuba on old lands so exhausted that cane plantings run out after two or three light cuttings, where a reasonable annual application of fertilizer and good cultivation has not only resulted in considerably increased crops at the first cuttings but has prolonged the life of the fields from two or three to eight or ten years. He has published in Circular 19 (Oct., 1905) of the Estación Agronómica de Cuba a photograph showing on the one side a vigorous field of ratoons going to their fourth cutting and on the other a grass field with one lone remaining stalk of cane. Both lots were planted at the same time. The one only showing grass was not fertilized, the other received 500 pounds per acre of a complete chemical fertilizer when planted but it had not been fertilized since, the residual effect of the one application still keeping the cane in comparatively good health and vigor while the unfertilized cane had entirely disappeared. This was undoubtedly an unusual case but it clearly illustrates the point under discussion, which is that a large percentage of the annual losses from root disease are easily preventable by following the simple agricultural practices mentioned in Circular 17 of this Station.

Unfortunately, the finding of a true parasite, the vascular bundle fungus, shows that not all of the losses can be prevented in this simple manner. Our studies so far do not indicate how serious a factor this may prove to be in the general complex, but it is entirely unlikely that it can be controlled by cultural methods. In the variety experiment at Santa Rita, the results of which have been already discussed, this organism was frequently found. The disaster which overtook that field notwithstanding fairly good cultural conditions seemed to depend on the complication with the severe infection of Mosaic disease rather than on the presence of this organism. The Mosaic disease by its influence in reducing vitality and inducing premature maturity is a factor exactly fitted to promote injury from root disease.

Aside from the selection of resistant varieties and the use of reasonably good cultural methods, one other point requires attention, and that is proper selection and handling of seed cane. The bundle fungus is undoubtedly transported and planted in the seed. There

is less danger of this where top seed is planted and less danger when young plant cane is used than with old ratoons. In planting the entire cane for seed as in *gran cultura* the butt-cut should be rejected, as this is more likely to carry the bundle fungus and besides the bottom leaf sheaths are likely to be matted by the mycelium of *Marasmius* and other undesirable fungi. The seed cane, too, should be inspected and the butts should be cut off in the field where cut. The common practice of hauling the cane to the side of the new field and doing this work there is objectionable since it leaves the infected butts and discarded canes on the border of the new field with every chance for infecting it.

Dipping seed cane in Bordeaux mixture will have little or no effect in preventing root disease. This treatment serves to protect the seed piece from the entrance of the pineapple-rot fungus (*Thielaviopsis*) or other rot-producing organisms. It can have no effect on the bundle fungus and will have little or no effect in preventing root killing by *Rhizoctocnia*, *Pythium* or other facultative parasites.

SUMMARY.

1st. Root disease as here understood is a complex including phases often known as Root Rot, Wither Tip, Top Rot and Rind Disease. These phenomena are caused by a number of facultative parasites, none of which attack actively growing vigorous tissues. There is also a heretofore unknown true parasite inhabiting the vascular bundles. *Rhizoctonia* and *Pythium* are the usual root-killing agents rather than *Marasmius* and *Himantia*.

2d. Cane varieties differ greatly in their resistance or susceptibility to Root Disease. The Otaheite or Caña Blanca is very susceptible. North Indian canes like Kavangire and those with part North Indian parentage are very resistant or practically immune.

3d. Remedial or preventive measures include—

A. The planting of resistant varieties.

B. Better cultural methods to overcome facultative parasites.

C. Proper seed selection and handling.

INVESTIGATIONS OF ROOT DISEASE OF SUGAR CANE.

By J. Matz.

The root-disease problem of sugar cane has engaged the attention of many workers in the past, including the work of A. Howard on "Some Diseases of the Sugar Cane in the West Indies," published in 1903 in the Annals of Botany V. 17, pp. 373–412, in which the author gives an account of his experiments to establish a relation between *Marasmius sacchari* Wakker, and the root disease of cane in Barbados. From those experiments it appears that *Marasmius* is capable of causing damage to the sugar cane during certain unfavorable seasons. Under favorable conditions for the growth of the sugar cane plant the presence of the fungus on the plant did not seem to have a deleterious effect. The question arises if unfavorable seasons and unfavorable conditions in the field alone are not sufficient to produce an effect that might be similar to that which may result from a fungus attack on the roots of the plant. The fungus *Marasmius sacchari* is very common in a large part of the cane fields of Porto Rico and it has generally been taken to be the cause of root disease here. Johnston and Stevenson while describing root disease of cane in the JOURNAL OF THE DEPARTMENT OF AGRICULTURE OF PORTO RICO, Vol. 1, No. 4, 1917, express doubt as to "the exact status of root disease with respect to the parasitism of *Marasmius, Himantia, Odontia,* or possibly other forms, * * * while it is generally held that *Marasmius* at least is a true parasite really definitive evidence is lacking." During the past year an attempt was made to determine, if possible, the exact nature of root disease of cane, and, the facts thus far learned are of sufficient interest to warrant their publication.

WHAT IS ROOT DISEASE OF CANE?

By root disease of any plant it is usually understood to mean decay of roots which result in either the rotting of the basal part of the plant or in a mere stunting and subsequent withering of the whole plant. In either case the symptoms should be clear enough as not to confuse it with other diseases. In cane there are many plants which could easily be taken as affected with root disease that may not be suffering from root disease at all. Borers of various

kinds, drouth, lack of cultivation, gum disease, top rot, and lack of drainage produce effects that may be taken for root disease. The cane plant as a whole has such a structure that injuries to the lower portion whether caused by mechanical agents such as boring insects or by the physical conditions of soil, or whether by fungi and bacteria which either clog up the conducting channels or fibers thus starving the plant or simply decompose the roots through parasitism, the effects on the plant as a whole in all cases would be drying of leaves from the tips, top rot, stunting and shortening of the joints and a multiplicity of short sprouts. Therefore to distinguish root disease proper from other troubles of the cane which arise in the root region the term root disease is restricted here to mean a decomposition of roots taking place on account of the invasion of fungi. The symptoms of root disease therefore are primarily a decomposition or lack of healthy roots, dry leaves and stunted appearance of the cane. Top rot may also result indirectly on account of lack of sufficient roots to take up and conduct necessary water and food to the plant. The binding of the lower leaf sheaths has been generally taken for a symptom of root disease; that is, when *Marasmius sacchari* was taken as the parasitic cause of the disease. That symptom is not necessarily an accompaniment when another fungus is concerned with the decay of roots. Cane ratoons which exhibit all the effects of root disease, being stunted and having the lower portions of the stalks covered with adhering dry leaf sheaths and yet binding was not observed and the yellowish white mycelium of *Marasmius* was not noticed in between them. It is, however, reasonable to assume that the same ratoons had they grown in low and moist locations and if *Marasmius* had been present in that soil that binding would have taken place, as the fungus thrives well on dead cane leaves and stalks. It is quite possible that under unfavorable conditions of growth the cane plant may fall a prey to an organism which is not parasitic enough to be able to attack the cane had it grown under conditions condusive to strength and vigor. Such cases no doubt exist. But the semi-parasitic organisms do not add much more damage to the amount which is already caused by the unfavorable conditions, which may be poor drainage, lack of water and no cultivation or undesirable varieties planted on unsuitable soil lacking in plant food elements. The important factor in true root disease should be an organism which is capable of attacking essential roots and destroying them. With this point in view a search was made

to find and isolate microorganisms from the interior of young but partially affected roots of cane. This effort was rewarded by finding *Rhizoctonia*, a root-destroying organism in the tissues of young roots, on seven different occasions, and *Pythium* sp. on two occasions. At the same time *Rhizoctonia* species were isolated from a large variety of plants other than cane, proving that this form genus is widely distributed in soils of Porto Rico.

THE ISOLATIONS OF FUNGI FROM CANE ROOTS.

The first isolation trial was made in December, 1918, immediately after the writer had become connected with the Insular Experiment

FIG. 1.—The two cane plants in the middle were inoculated, at the time of planting the seed, with *Marasmius*, the plant on the right with *Rhizoctonia solani* (?) and the one on the left is a check.

Station, from cane at the Santa Rita estate near Yauco. The cane plants were only a few months old from a *gran cultura* planting. The leaves did not show any abnormal appearances at that stage, except yellow-stripe disease in some plants. On pulling up some plants, both yellow-striped and healthy, it was observed that the roots of some, though numerous, were mostly brown and partly decayed. Although the brown coloration is natural with older roots, the young and fleshy rootlets, however, were stained an unnatural red and the root cortex was dissolved and decomposed in part. Two plants were brought to the laboratory, and the younger and red-brown root-

lets were cut off, washed in running water, and with a flamed scalpel bits of the reddish and soft tissue were planted in corn meal agar plates. In about two days three fungi were observed in the plates. One was *Rhizoctonia* with its characteristic even mycelium and anastomosing side branches, another was a *Pythium*, laterly determined as such by its fructifications, and several colonies of *Trichoderma*. These three fungi were transfered to several tubes containing sterilized green bean pods. The *Rhizoctonia* transfers began to form yellowish sclerotia in about four days. At first these sclerotia were composed of loose but short and stout hyaline hyphæ, later the masses became more compact and took on a deeper color. In about 3 weeks the mycelium in the tube became buff brown, and the sclerotia became darker and have attained a size of 1 to 3 millimeters. They are rounded and covered with a lighter growth of short hyphæ. The culture presents all the general characters of the well-known *Rhizoctonia solani*, of which the writer has a culture which was isolated in Florida and compared with a culture of the same from Dr. B. M. Duggar of the Missouri Botanical Garden. Whether this cane *Rhizoctonia* is identical with or is a different strain from *R. solani* is reserved for another paper to be published in the future.

INOCULATION EXPERIMENT.

Before searching any further for more fungi on cane roots an inoculation experiment was made to test the relation of the above-named three fungi to cane root decay. Rayada cane seed, each consisting of at least one entire internode and two nodes, were cut with a sharp knife about one-half inch above and below their respective nodes. These pieces were washed for 15 minutes in a 1 : 1000 solution bichloride of mercury, rinsed in running water and planted in steam-sterilized soil in six-inch pots. Three seed pieces were inoculated with the above *Rhizoctonia*, three with *Pythium* and three with *Trichoderma*. This was done by placing a bean pod culture of one of the organisms on the seed piece and covering it all with about one inch of soil. The pots were watered and kept covered with paper for three days from inoculation. On the fourth day the top layers of soil were removed and the young roots, some of which had attained one inch in length, were examined. It was found that where *Rhizoctonia* and *Pythium* were used some of the young roots were red and soft. Small pieces of the latter were examined with the aid of the microscope and it could plainly be seen that the two fungi had entered

and grown into the interior of the roots, causing a decomposition of the cells of the fleshy parts of the root. The characteristic *Rhizoctonia* mycelium, with its almost perpendicular branching and dis-

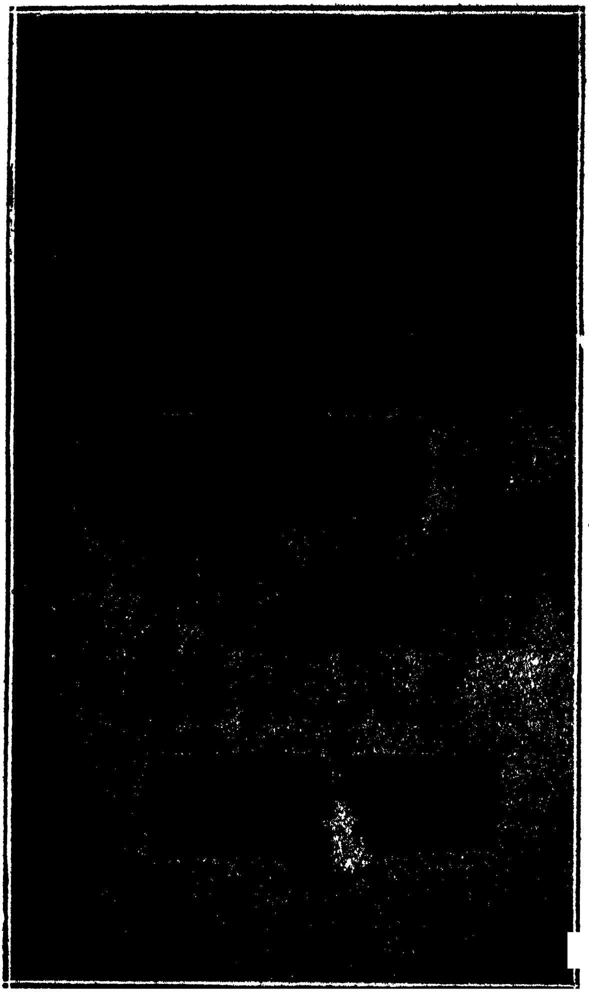

FIG. 2.—Inoculation experiment. *Marasmius* on left, *Rhizoctonia* on the centre seed piece, and *Pythium* on the seed on the right. Note the black roots caused by Rhizoctoria.

tinct walls could be seen to ramify in and between the cells of the roots in the parts where that fungus was used as the inoculum, and the stout, uneven and hyaline, non septate mycelium of *Pythium* was observed to have grown around and between many root cells in

the pots where this fungus was used. The fungus *Trichoderma* did not produce any visible change in the roots of the cane.

Having that much success with this first trial another experiment was made, using the three above-named fungi and in addition pure cultures of *Marasmius sacchari*, and *Odontia saccharicola.* Again *Rhizoctonia* and *Pythium* gave positive results while *Trichoderma, Marasmius* and *Odontia* did not affect the young roots. In this experiment six seeds were inoculated with *Rhizoctonia*, six with *Pythium*, three with *Marasmius*, three with *Odonia*, three with *Trichoderma* and three were left as checks. Two strains of *Marasmius* were used, one was from a culture growing in pure state on sterilized cane leaves in flasks, the other was isolated by the writer from spores of hymeniums collected in a cane field at Río Piedras. The two strains were similar in all appearances, the first one probably having come from mycelium commonly found on leaf sheaths and basal parts of cane stalks. The method employed to obtain spore cultures from *Marasmius* and *Odontia* was by making a spore print on sterilized corn-meal agar. A drop of agar was placed on the inside of a Petri dish cover and a portion of the hymenium was stuck onto the agar. Then the top was placed over a corn-meal agar poured plate permitting the spores to drop on the surface of the agar in the bottom dish. With fresh hymeniums a spore print on sterilized agar was thus obtained in 24 hours. Single spores could then be transferred from the edge of the print where they are not too thickly sown. Both fungi were grown on sterilized green bean pods. The growth of *Marasmius* in pure cultures, from single spores, was producing white strands similar in appearance to the fungus usually found in connection with binding of the lower leaf sheaths. Other cultures from the white mycelium, usually taken to be *Marasmius*, were also made and there was such an agreement of characters between these and the cultures from spores that the writer is inclined to the general belief that the common leaf-binding fungus in Porto Rico is no other than *Marasmius sacchari.* Further proof of the identity of the two forms was had by the fact that a culture of mycelium from matted leaf sheaths developed the spore-bearing stage of *Marasmius sacchari* when placed in soil in pots in which cane was growing. The cultures of *Odontia* spores were rather slow growing, producing a short, grayish and thin growth of mycelium on bean pods, after a while becoming water soaked and giving to the bean pod itself an oily or more or less transparent aspect. There were no formations of mycelial strands or threads in these

cultures. And the writer cou'd not find any similarity of character between these pure cultures and the thread mycelia commonly encountered on cane soils in the field

FIG. 3.—Sclerotial fungus on dead leaf of cane.

When the plants inoculated with *Rhizoctonia, Pythium, Trichoderma, Marasmius,* and *Odontia,* in the experiment mentioned above, were examined it was noticed that in the *Marasmius* pots, although the white threads of the fungus had penetrated through the upper

three or four inches of soil, the growing roots of the cane seed were not affected in any unusual way. Mycelium was observed on some roots but no rotting took place. However, after three months from inoculation there could not be seen any appreciable difference in the growth between any of the inoculated plants and those used as checks. A liberal amount of water has regularly been applied to the plants. When the water was cut off for two or three days, the ones inoculated with *Rhizoctonia* showed less vigor. Four months from inoculation the pots inoculated with *Marasmius* produced the fruiting stage of the fungus at the same time the cane plants were among the tallest and most vigorous ones. Fig. 1 is a photograph of four plants in this experiment. The two middle ones have been inoculated with *Marasmius* and are showing the fruiting caps of the fungus growing in the soil and at the bases of the young cane stalks. The plant on the left is a check, and on he right is one in which *Rhizoceonia* was used as the inoculum.

All the plants in the last experiment were later taken out of the pots and their root systems examined. It was apparent that the roots from the plants infected with *Rhizoctonia* were fewer in number and that many of the longer roots were brittle and decayed: the the same was noticed where *Pythium* was applied to the soil; in the case of *Marasmius,* although the fungus mycelium was plainly visible in amongst the soil particles, yet the roots did not show as much decay as in the first two; the same was true with the *Odontia* and *Trichoderma* infected plants. The roots of the check plants were normal. The plants were then set out in the field. All of them made a uniform growth with the exception of a larger number of dead lower leaves being present on those which were previously infected with *Rhizoctonia.*

At maturity the cane, all of which made a very good stand, was cut and allowed to ratoon. In the ratoons an unevenness of growth in the centre of the plot was observed. This unevenness was no doubt due to soil conditions, as the effect of the previous inoculations were entirely lost during the first season of growth after the transplanting to a new location. In this small plot of cane there became evident a stunting of the cane in a central area, a phenomenon which is not unusual in cane fields. In this particular case, the uneven stand in the cane was evidently due to a very compact soil, which became more so in the center of the plot during a season of heavy rainfall.

In order to make close observation of the relation of the above-mentioned fungi to root decay of cane a series of moist chamber inoculations were made as follows: Seed pieces of cane containing one or two buds were sterilized in a solution of 1:1000 bichloride of mercury and placed in sterilized and moist glass jars. Cultures of *Rhizoctonia, Marasmius* and *Pythium* were placed on the cane seed and the jars were covered with glass. Fig. 2 is a photograph of three seeds in this experiment. *Rhizoctonia* has in two weeks invaded

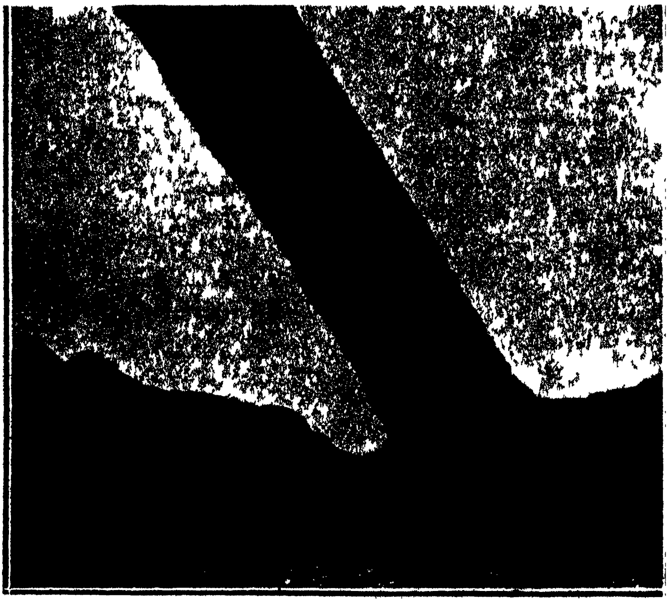

FIG. 4.—Sclerotia at the base of an inoculated cane plant.

the growing rootlets, the threads of the fungus growing on the whole length of the rootlets. Instead of being white or yellow the rootlets turned reddish brown and the smaller roots, or those which have arisen after the fungus has had time to develop its growth, did not attain any considerable length and they were abnormally brown instead of purple at the tips. Compact masses of the mycelium were plainly visible in the softened tissues of the attacked rootlets. Reisolations gave the same type of *Rhizoctonia* from these roots. *Marasmius* grew right alongside of the roots of seed on which it was

placed, but there were no striking differences of any abnormal nature in appearance of these roots and the roots of seed in the check jars. Although the fungus mycelium of *Marasmius* was in contact with the roots there was no sign of decay in them. *Pythium* did not have the same injurious effect upon the roots as *Rhizoctonia* in this experiment. However, a few roots were observed to have been attacked and upon reisolation the same fungus was recovered. Experiments such as described above have been repeated several times, using different varieties of cane, and employing other strains of *Rhizoctonia*. The results have not always been uniform mainly due to the fact that other fungi and ferments would enter and cause decay of the seed pieces thus preventing normal development of roots. On several other occasions the inoculum would not grow in the jars as described, due, perhaps, to an early chemical change in the seed itself.

That the condition of the seed piece in itself plays an important part in the health of the first series of roots that arise at the time of germination has been observed on several occasions. For example, in one experiment mature Otaheite seed were used in the jars, the seed being placed on one end in the bottom of the jars in about one-fourth inch of tap water. Not a single seed out of 24 germinated and the roots did not make much headway before they became arrested in growth and finally decayed. On the other hand, the same treatment when accorded to Rayada and Caledonia did not produce in them any growth-inhibitory symptoms. The seed pieces of the latter two kept sound and their roots in most of the jars attained normal lengths and were abundantly side branched. However, the seed of these two varieties if infected with the yellow-stripe disease produced many short-lived, red, roots when placed in moist jars as above. Of course, the cane bud produces its own roots after a while, but during the early stages of its growth it is dependent upon the mother seed piece and its root system in order to make good growth. If the seed piece is liable to become fermented sooner, either because of its natural lack of hardiness or because it was allowed to become weak on account of too prolonged exposure between the time it was cut and the time it was set in the ground, it is quite certain that it will give weak shoots which will be short lived mainly because such seed do not produce enough and vigorous roots.

Another form of *Rhizoctonia* was found in its sclerotial stage on

the lower dead leaf sheaths of cane. (Fig. 3.) Kruger[1] in describing diseases of cane mentions three diseases which are associated with three distinct sterile fungi but which produce sclerotia. One of these, causing the red rot of leaf sheaths ond stalks, is *Sclerotium Rolfsii*, as can be plainly seen from Kruger's colored plate XIV. Another sclerotia-producing fungus he associates with the sour rot of the leaf sheaths. This fungus, he states, produces sclerotia of light orange-yellow color, are larger and softer than the former (*Sclerotium Rolfsii*). The fungus with the orange-yellow colored sclerotia is unknown to

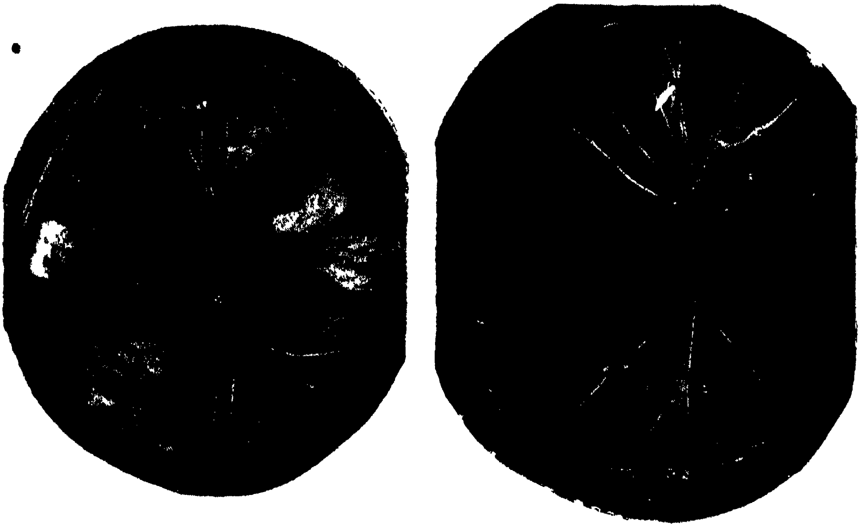

FIG. 5.—Seed on the left inoculated with pure culture of sclerotial fungus, showing many black or diseased roots, seed on the right not inoculated, all roots being white.

the writer. On pages 443–447[1] Kruger describes and illustrates a disease under the name of sclerotia disease of sugar-cane leaves. The fungus associated with the disease is most likely identical with the Rhizoctonia under discussion. The thin mycelium of this fungus is hardly noticed, but its gray to dark-gray and sometimes gray-brown scletoria which are more or less rounded, concave and sometimes ridged are commonly found in damp and shaded locations on dead leaves near and sometimes on the ground. The fungus was grown in pure culture from bits of sclerotia in corn-meal agar and

[1] W. Kruger, Das Zuckerrohr und seine Kultur. 1899, pp. 438–466.

on green bean pods. When a pure culture of the fungus was placed in sterilized soil in pots the mycelium grew rapidly in the soil and sclerotia were formed in large numbers on the moist surfaces of the soil and the walls of the pots. Pure cultures of the fungus were placed on seed cane in sterilized soil and the growth of the fungus on the young shoots and roots was observed (Fig. 4, 5, 6.) The shoots became reddish-brown and dry at their bases and began to dry at the tips as well. The fungus mycelium and sclerotia were adhering to the lower parts of the young cane shoots. Other seed planted at the same time and under similar conditions, but the soil in which these grew was not inoculated with the fungus, produced vigorous shoots. In order to prove whether this fungus is capable of attacking green leaves and their sheaths above ground, portions of growth of the fungus produced in culture tubes were placed on green leaves and sheaths of cane and covered with glass chimneys. The growth of the fungus on these was rather slow, it produced lesions of various sizes, the largest being one-half inch in length on one leaf. In all cases it produced one or more sclerotia which were identical with those from which the cultures were made.

Pure cultures of the same fungus were placed on young roots of cane seed placed in sterilised moist chambers. The fungus mycelium grew over the roots and it was noticed that many of the roots soon became partially brown. Upon examination it was found that the fungus has penetrated into the soft tissue of the roots, and portions of these when planted in agar gave the identical fungus upon reisolation.

CHARACTER OF THE FUNGUS.

The fungus agrees with the general characters of the form-genus *Rhizoctonia*. Stevenson in the Annual Report of the Insular Experiment Station, of 1917, page 138, describes the fungus as *Sclerotium griseum*. This fungus is, according to the description and herbarium specimens deposited by him at this laboratory identical with the above *Rhizoctonia*. The sclerotia do not possess a distinct cortex, are not smooth and are homegenous in color throughout. When this fungus is grown in culture tubes on sterilized bean pods it presents a very similar appearance to the growth of *Rhizoctonia solani* with the exception that the latter is darker brown. Other forms of *Rhizoctonia* similar to the *Solani* type have been grown by the writer in

pure culture and which were very light in color. The sclerotia of the above cane fungus are very irregular, flat and more or less loose in texture when produced in culture tubes on bean pods. Since this fungus agrees more with the form genus *Rhizoctonia* than with *Sclerotium* the name ***Rhizoctonia grisea*** (n. comb.) is proposed.

FIG 6.—Effects of sclerotial fungus on young shoots of cane.

SUMMARY.

Sugar cane roots, like many other plants, are attacked by the well-known fungi belonging to the genera *Rhizoctonia* and *Pythium*.

These fungi are common in the soils of Porto Rico.

More than one form of *Rhizoctonia* has been isolated from diseased roots of cane.

A NEW VASCULAR ORGANISM IN SUGAR CANE.

By J. Matz.

In studying the internal structure of cane affected with yellow-stripe disease and cane which was free from this disease but which was affected with top rot or rather dry top, it was observed that the annular and spiral tracheides and pitted vessels in the fibro-vascular bundles, in the lower internodes of both classes of cane mentioned, were plugged with an organism consisting of spherical orange-brown colored spores embedded in a yellowish hyaline matrix. (Fig. 7.) Later this same occurrence was detected in roots of cane as well. Sometimes the vessels were filled with a mass of granular protoplasm containing all stages between numerous small immature ovate bodies of various sizes and the mature, spherical, larger spores. The larger spore bodies have more or less thickened, smooth walls with an interior of a darker, orange-brown mass of granular protoplasm; are uniformly spherical in shape but vary slightly in size; they meausde from .014 to .016 millimeters in diameter. The smaller bodies, when pressed out of vessels under a cover glass, vary in size and form. They vary in size from four microns in diameter to nearly the full size of the larger spherical bodies. In form the smallest are devoid of any distinct wall and appear like an irregular dense granule; however, the larger of these possess a densely granulated small center surrounded by a hyaline mass of cytoplasm which is several times thicker than the central granular part. (Fig. 8.) At this stage the small bodies, owing to the soft consistency of their outer part, are mostly oval, due to pressure they exert on each other in the interior of the vessels. The cytoplasmic hyaline layer becomes thinner and the center larger as the individual grows into maturity. The actual growth of these organisms has not been observed as the mature spherical bodies have not germinated in several attempts made, but as the various smaller immature and the spherical mature bodies have been found in the interior of the same fibro-vascular bundles and even in the same vessels it is only reasonable to assume that they represent different phases in the life history of one or-

ganism. In examining fibro-vascular bundles it was found that the lowest portions contained the mature spore bodies and that these diminished and the smaller ones increased in numbers towards the upper part so that at the uppermost point of their visible penetration only granular cytoplasmic masses were found. In some bundles the organism appeared only as a mass of granulated nearly hyaline cytoplasm.

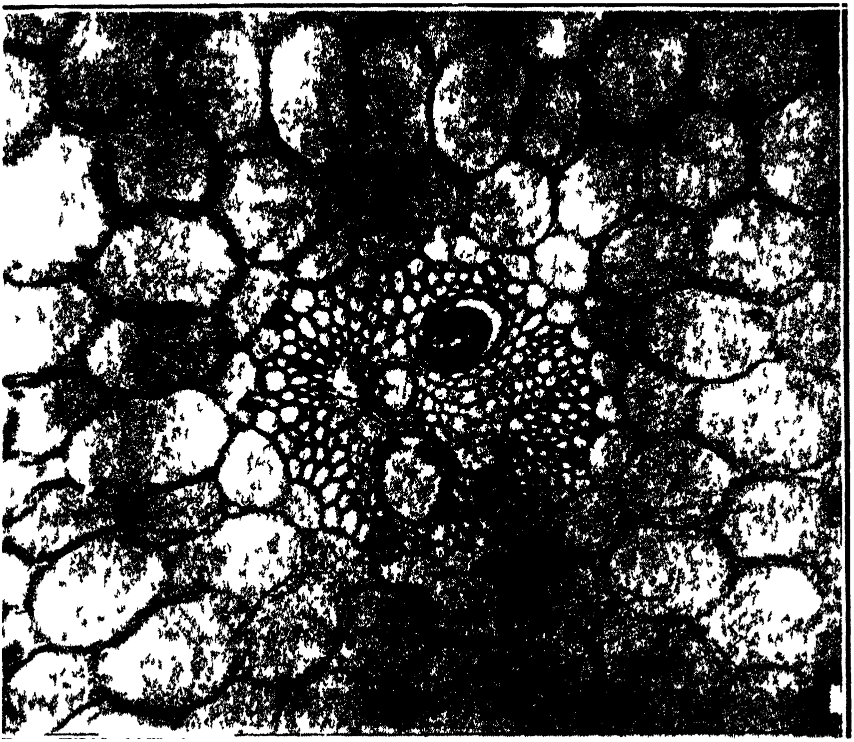

FIG. 7—Fibro vascular bundle of sugar cane, showing plugged tubes and vessels with spherical spores × 100

The presence of this organism can be detected in cane which show, upon splitting lengthwise or cutting cross wise, bright yellow or orange-colored, sometimes reddish fibro-vascular bundles. These are usually located in the root region of the underground portion of the stalk. The number of orange or reddish-colored bundles in the cane examined were variable. Some canes showed only three

or four colored bundles and in sectioning these it was found that they were plugged with the above organism only for about two or three inches through the lowest nodes and internodes. Others have been found to be infested to a larger extent; that is, the organism was present in a majority of the bundles which were orange colored or reddish and to a height reaching the uppermost nodes. The degree of prevalence of the organism in cane is no doubt due to whether the cane has been growing in more or less infected soils and whether the seed was infected with the organism before planting.

It must be stated here that the fibro-vascular bundles of cane, due to various effects, become sometimes red, vinous or brown in color. To the naked eye it is sometimes difficult to distinguish be-

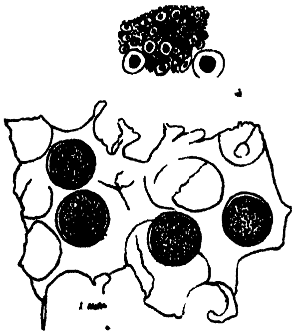

FIG. 8. — Camera lucida drawing of mature spores imbedded in a hyaline matrix, above immature spores. × 400.

tween these and those which are infested with the above organism. Moreover, bundles infested with the latter are sometimes bright red, due to a later effect of the death of the phlœm. Nevertheless many specimens have been recognized in the field as being infected with the above organism by the symptoms described in the previous paragraph, and this diagnosis proved correct later with the aid of the microscope. A homogenous, jelly-like, sometimes colored substance is sometimes found in the vessels of injured cane. This substance differs from the above organism in its lack of granulation. Gumming disease can be distinguished by its yellow exudation.

THE DISTRIBUTION OF THE ORGANISM IN PORTO RICO.

The first discovery of the organism was made in the fall of 1919 in yellow-striped diseased Cavengerie cane at Bayamón; later it was

found at Río Piedras in non-yellow-striped cane of a Porto Rico seedling. It was also found at Mayagüez in the varieties Otaheite and Crystalina, at Santa Rita in Rayada, near Cayey in Rayada, near San Germán in non-yellow-striped Crystalina and near Loíza in D-109. In all of these localities cane is known to suffer from what is usually known as "root disease." In looking for the organism

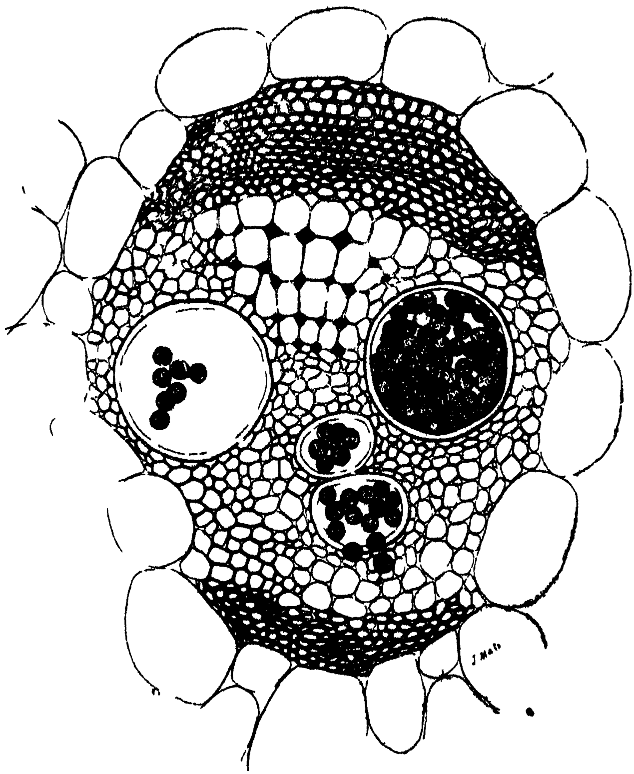

FIG. 9.—Camera lucida drawing of a cane bundle, showing the distribution of the organism in the vessels. × 133.

it was observed that it occurred in cane which showed symptoms of stunting and the tops of which were either partially or totally dry, effects which are commonly attributed to root disease.

THE RELATION OF THE ORGANISM TO THE GROWTH OF CANE.

From the mode of occurrence of the organism in cane, and the manner of its plugging the conducting vessels in the vascular system

of cane it is quite natural that an interference with growth should result. At first an attempt was made to germinate the spores of the organism in water, in sugar water, in cane juice, in fermented but sterilized cane juice, and in several agars but no germination was observed to have taken place. Spores were kept in moist cells for over six months and no germination was observed to have taken place. Portions of cane stalks which contained bundles filled with the organism in its several stages were cut and placed in moist chambers together with healthy seed pieces of Rayada cane, and after five months it was found that the roots of the Rayada cane contained many of the spherical spores of the organism. Apparently a transfer of the organism from its original seat into the healthy cane had taken place. Inoculations with bits of infested bundles into six healthy canes were made a the basal regions of the latter. The six cane stools thus inoculated show marked stunting in contrast with other uninoculated canes growing along side of the former. The important fact is that the organism is able o plug the free passage of the fibro-vascular system in cane, as it is found in that condition in the field. (Fig. 9.)

There seems to be no mention of such a phenomenon in sugar cane in literature on the subject of cane diseases. It is apparently an organism hitherto undescribed.

No mycelium of any kind has been observed to be directly connected with any of the spore forms of the organism. The spores are free in the vessels of the host plant, and the plasmodium is limited by walls of the vessels of the host. Therefore it agrees with the characters of the family *Plasmodiophoraceæ.* It differs from *P. brassicæ* in that it does not form galls and that it inhabits the vascular system of its host. The spores of *P. brassicæ* are smaller than in the organism of sugar cane.

NAME OF THE ORGANISM.

Plasmdiophora vascularum, n.-sp.

Description.—The spores in their advanced stage in the interior of the vessels of fibro-vascular bundles are spherical with smooth, somewhat thick hyaline walls, evenly granulated or sometimes coarsely granulated in the interior, orange, yellow, sometimes slightly brown in color, measuring .014—.016 millimeters in diameter. Spores are

embedded in a yellowish hyaline, at length hard matrix. Plasma is composed of a mass of granular cytoplasm, later developing into individuals composed of clear, cytoplasmic variable bodies having a dense, darker, granular center.

Habitat—Mayagüez, Río Piedras and other localities, in cane fields, Porto Rico. In vascular system of sugar cane, *Saccharum officinarum* Linn

PUBLICATIONS OF THE YEAR (1919–1920).

(Published or in Press.)

1. Annual Report of the Insular Experiment Station of the Department of Agriculture and Labor (1918–1919) of Porto Rico.
2. Journal of the Department of Agriculture, Vol. III, No. 3, The Mottling or Yellow Stripe Disease of Sugar Cane, by John A. Stevenson.
3. Bulletin No. 19. The Resistance of Cane Varieties to Yellow Stripe or the Mosaic Disease, by F. S. Earle.
4. Boletín No. 20. Insecticidas y Fungicidas, por I. A. Colón.
5. Circular No. 17. Recomendaciones Sobre el Cultivo de la Caña de Azúcar en Puerto Rico, por F. S. Earle.
6. Circular No. 18. El Exterminio de la Garrapata, por J. Bagué.
7. Boletín No. 21. Abonos (1918–1919), por F. A. López Domínguez.
8. Bulletin No. 22. Eradication as a Means of Control in Sugar Cane Mosaic or Yellow Stripe. The Year's Experience with this Method, by F. S. Earle.
9. Circular No. 19. La Preparación de Abonos Mezclados por el Agricultor, por F. A. López Domínguez.
10. Boletín No. 19 (Edicion Española.) La Resistencia de las Variedades de Caña a la Enfermedad de las Rayas Amarillas o del Mosaico, por F. S. Earle.
11. Boletín No. 22. (Edición Española.) La Extirpación del Mosaico de la Caña como Medio de Represión, por F. S. Earle.
12. The Journal of the Department of Agriculture Vol. IIII, No. IV. Yellow Strips Investigations, (Progress Report).
13. Circular No. 20. La Gomosis de la Caña, por J. Matz.
14. Circular No. 21. El Cólera del Cerdo, por Dr. Jaime Bagué
15. Circular No. 22. El Mosaico de la Caña o Matizado, por F. S. Earle.
16. Circular No. 23. Variedades de Caña, por F. S. Earle.
17. Circular No. 24. La Preparación de la Disolución Arsenical para el Exterminio de la Garrapata, por F. A.López Domínguez,
18. Circular No. 25. El Mal del Guineo, por J. Matz.

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PORTO RICO

THE WHITE-GRUBS INJURING SUGAR CANE IN PORTO RICO

II. THE RHINOCEROS BEETLES

BY

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SAN JUAN, P. R.
BUREAU OF SUPPLIES, PRINTING, AND TRANSPORTATION
1920

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THE WHITE-GRUBS INJURING SUGAR CANE IN PORTO RICO.

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II.

THE RHINOCEROS BEETLES.

It has been pointed out in a previous publication that white-grubs may include the larvæ of any of the large *Scarabæd* beetles of the *Lamellicorn* family, which is divided into two tribes, the *Melolonthini* and the *Dynastini*. In the former tribe five species have been described by the writer, four in the genus *Phyllophaga* (*Lachnosterna*) and one in the genus *Phytalus*, and the habits and life-history of these have been described at length in this JOURNAL, Vol. I, Nos. 2 and 3, under the title "Life-Cycles of the May-Beetles or *Medolonthids*."

In the tribe *Dynastini* are five other species of white grubs, of which two species are considered in the present paper, both belonging to the genus *Strategus*.

THE GENUS STRATEGUS.

This includes a considerable number of species, which are widely distributed over Southern North and Central America, the West Indies, and Northern South America. There are perhaps a half dozen other species, besides the two here discussed, found in the West Indies,

[1] The unfinished condition of this paper has necessitated its being turned over to and edited by Mr. G. N. Wolcott, Mr. Smyth's successor as Chief Entomologist of the Insular Experiment Station.

none of which, however, is as widely distributed as either of these two.

All the species of *Strategus* have similar habits, living for the most part in decaying wood. Only in tropical countries, however, and especially in isolated districts or islands where the continued denudation of the native forest growth has driven them to live upon sugar cane and palm trees, have they assumed economic importance or been accused of damaging crops. There can be no doubt that clearing away of forest growth and removal of their natural food has greatly altered their habits. This is strikingly illustrated in the Island of Vieques, lying just east of Porto Rico, where the timber has been practically all removed, and where as consequence the smaller species of rhinoceros beetles, *Strategus titanus* Fab., has become more injurious to sugar cane than in Porto Rico.

THE NAME "RHINOCEROS BEETLE."

The reason for calling the various species of *Strategus* "rhinoceros beetles" is the fact of their having usually, at least in the male sex, one or more large, prominent horns on the fore part of the body. Only the males develop horns, and these vary in size from small tubercles to projections nearly an inch in length, all borne on the thorax. Usually the horns occur in a triangle, one forward and two back, the front horn being the longer, and curved upward (see plate 4, Fig. 1). By means of these horns the powerful male beetles can tear their way easily into mature sugar cane, and even into the solid wood of the coconut palm. The males use the horns also in fighting, and engage often in long battles The size of the beetles, as well as of the horns, seems to be determined largely by the amount of food that was available to the larva during its period of feeding. At least, in our breeding experiments the best-fed larvæ have produced the largest adults, and in the case of males, those with the largest horns. In no case does a small male have prominent horns, nor a large male reduced horns

It should be noted that the true rhinoceros beetle, which is a pest of the coconut occuring in Samoa and other Pacific Islands (*Oryctes rhinoceros* Lind.) is more worthy of this name than are our own species, as it bears the horn on the head instead of on the thorax, and is able to wield it with the same upward, ripping motion as does the African and Asiatic mammal from which it is named. As there is, however, no representative genus *Oryctes* in the western hemisphere, the species of *Strategus* have acquired the same popular name.

The true rhinoceros beetle, mentioned above, is perhaps best known as a pest of coconuts in Samoa, where it was introduced some years ago and has since been inflicting great injury to the coconut palms, due supposedly to the fact that its natural enemies were not introduced with it. The species occurs also in India, Ceylon, Java, Sumatra, Celebes, Borneo and the Philippines, and in all of these localities it is injurious to the palms.

A somewhat similar beetle found in the Solomon Islands, *Trichogomphus semilinki* Ritz., is known as the Solomon Island rhinoceros beetle, and is injurious especially to the coconut palm. In this species also, the horn is on the head.

Another related genus, *Pentadon,* also includes beetles of large size with horn or projection on the fore part of body and they are notably injurious to crops. *Pentadon australis,* occurring in Queensland, attacks the stalks of sugar-cane below the ground as do the larvae of *Strategus titanus* in Porto Rico. *Pentadon idiota* Herbst. (*P. monodon* Fab.) occurs in southern Russia as a pest of corn and various grain and root crops. *Pentadon punctatus* is recorded as a pest of the grape vine in western Europe. Other species of the genus occur as pests in southern Asia and western Africa.

One of the most remarkable beetles of the *Dynastid* group to which *Strategus* belongs is the Solomon Island elephant beetle, *Xylothupes nimrod* Voet. (= *X. gideon* Linn.). This beetle sometimes reached a length of three inches, which is only slightly greater than our larger *Strategus* (*S. quadrifoveatus* Beauv.). The male has two horns, one on the head and one on the thorax, curved toward each other at the tips in such manner that they form a huge clasper which the beetle can close firmly by an upward movement of its powerful head. These horns vary from a fraction of an inch to over an inch in length, in different individuals. Like the rhinocerous beetle of the Solomon Islands, this is an important coconut pest. It is distributed through Java, Sumatra, New Guinea, the Malay Archipelago, and the Solomon and neighboring islands. A closely related species with similar habits, *Xylotrupes australicus,* occurs in Queensland.

In our western hemisphere, a species of rhinoceros beetle, *Strategus anacheoreta* Burm. has been recorded as damaging coconut palms in the island of Trinidad, and the same species occurs also in Cuba, where it doubtless does similar damage.

In both North and South America there are the large so-called

"Hercules Beetles," belonging to the genus *Dynastes*. They are most closely related to the Solomon Island elephant beetle, but have not been recorded as pests.

LIFE-HISTORY WORK ON RHINOCEROS BEETLES.

Researches into the habits and life-cycles of the Porto Rican rhinoceros beetles were begun early in the summer of 1913, at the same time that the life-history work on the May-beetles was begun. In an insectary erected at Santa Rita, on the south coast, were conducted, during the succeeding three years, the studies on the life-cycles of white grubs, which were summarized on page 47 of the Fourth Report of the Board of Commissioners of Agriculture of Porto Rico (San Juan, 1916). In this table it is shown that both species of *Strategus* required about a year for their complete development, the total egg-to-adult period averaging 338 days for *S. titanus* (from 13 completed rearings) and 430 days for *S. quadrifoveatus* (from 2 rearings). Since the date of publication of this table, much additional work has been done on the rhinoceros beetles and more accurate information secured, particularly in the case of the smaller species. The information thus secured, and the detailed life-history studies, are presented here for the first time.

METHODS OF REARING THE BEETLES.

It is a comparatively simple process to rear *Strategus* adults from the egg by carefully observing certain details. The jar in which the female beetle is confined for eggs should be large and contain sufficient earth, and be examined often enough, so that her movements do not destroy the eggs she has laid. It should contain enough wood or fibrous material so that she may enclose her eggs in fiber cells rather than soil, and she should also be supplied with fresh food frequently in the form of cane cuttings. The male should not be confined continuously with the female as he molests her and prevents egg laying. Soil with the female should be sifted and should be damp, but not wet enough to gum up her legs. A six-inch depth of soil in a battery jar six to eight inches in diameter is sufficient.

When eggs are separated from the soil they are best kept in petri dishes, on the surface of moist sifted soil, where the proper humidity can be maintained to allow them to expand naturally, and at the same time their enlargement and hatching may be observed.

As the young grubs hatch they should be kept singly in 3-inch seamless tin boxes containing equal parts of moist, sifted soil and rotted wood. They should be examined at weekly intervals, and

fresh rotted wood supplied as needed. All the earth and wood in the tin boxes should be replenished occasionally to prevent accumulation of mites, which attach themselves in great abundance to the grubs and may so molest them as to cause them to molt imperfectly and sometimes prevent growth, and ultimately cause their death. After the second molt the grub should be transferred to a 4-inch round tin box, 1 inch in height, in which it may be reared to maturity. The mature grubs should be given wood only (and no soil) as they consume it rapidly. Wood of a pithy consistency is preferable. The boxes containing mature grubs should be weighted down to prevent grubs from pushing off the lids and escaping. When the full-grown grub is ready to pupate it forms an elongate, smooth, hard-lined cell. Daily examinations of the box should be made to obtain exact date of pupation and of emergence of adult. Several days pass before the adult becomes hard and begins to dig about in the box.

Both species of *Strategus* grubs thrive well on rotten wood. The smaller species (*S. titanus*) may be reared equally well on dry, half-rotted fragments of cane stalks, on filter-press cake (*cachaza*), or on dry horse or cow manure.

THE SUGAR-CANE RHINOCEROS BEETLE.

Strategus titanus Fab.

This species is called the sugar-cane rhinoceros beetle as it is of economic importance only in connection with the sugar-cane crop. The exact extent to which it injures this crop is difficult to determine, since its grubs occur nearly always in company with those of *Phyllophaga* and *Diaprepes,* both of which may exceed the *Strategus* grubs in numbers but are less apt to be observed by one examining the cane field, the *Phyllophaga* grubs because they are smaller and occur deeper in the soil than those of *Strategus,* and the *Diaprepes* grubs because they are well hidden within their tunnels in the underground stalks. Thus damage to a cane field is often blamed upon grubs of this rhinoceros beetle which in fact was due to the work of *Phyllophaga* grubs.

In February and April, 1913, Mr. D. L. Van Dine, formerly entomologist of this Station, visited a cane field in Hacienda Florida at Santa Isabel, near Ponce, on the south coast, where the field manager had reported serious injury by the *gusano de palo viejo,* as the *Strategus* grubs is known locally. Numerous specimens of the grubs of *Strategus titanus* were found in the soil about the plants, and

it was concluded that they were responsible for the bad condition of the cane, which was very yellow and sickly in most of the fields. As one of two *Strategus* larvæ found in the field were attacked by *Metarrhizium* fungus, another visit was made to the field on May 6 and 7 by Mr. T. H. Jones, then assistant entomologist of the Station, to obtain more of the grubs infected with the fungus. On this visit 44 cane stools, were dug up in the same field, to an average depth of a foot and a diameter of 18 inches, with the following results: *Strategus titanus* grubs, pupæ and adults, 16; *Phyllophaga* grubs, pupæ and adults, 315; *Diaprepes* grubs and pupæ, 77. In other words, there was an average but one *Strategus* to each three stools, but an average of 7 *Phyllophaga* and 2 *Diaprepes* to each stool. This clearly demonstrated that *Strategus* grubs, being the more evident, were blamed for the damage in large part committed by the May-beetle larvæ and the root-weevils.

FEEDING HABITS.

In the older records in our files bearing on this species, the observation has been frequently made that grubs of this beetle had damaged cane roots. But these grubs do not eat roots. In fact, grubs confined in sifted soil, destitute of organic matter, have starved when fed only upon young corn roots.

In the field, grubs of *Strategus titanus* are to be found about cane plants, and boring among the underground stems largely because of the large amount of organic matter that occurs in such situations. What damage they cause results entirely from the occasional severing of the underground stalks by the larvæ, together with the fact that their feeding about the bases of plants inadvertently severs a part of the roots. The mature *Strategus* grub is a voracious feeder, and there can be no doubt that when several of them are present in a stool, their activities cause considerable injury to cane plants But it is an accidental injury, and when unaccompanied by May-beetle and *Diaprepes* attack, by root disease or by severe drought, it could hardly seriously retard the growth of the cane.

On the other hand, if unusual numbers of *Strategus* grubs are present in a cane field and at same time the cane is suffering from other adverse influences such as drouth or disease attack, or perhaps from poor soil and inadequate fertilization, then attack of the grubs may be severely felt.

The adults of this species do not cause any direct injury to cane, though they do bore into the base of the stool for oviposition, and feed occasionally upon the underground stems.

DISTRIBUTION AND HABITAT.

Besides Porto Rico, this beetle has been recorded as occurring in Cuba, Jamaica and the Virgin Islands. It has also been collected by the writer in Vieques and in Santo Domingo.

In Porto Rico its occurrence is general, though it seems to be considerably more abundant in the drier than in humid districts, and all records of its injury to sugar cane come from the Aguirre, Ponce and Guánica districts of the south coast. Dozens of the grubs were collected in manure heaps in coconut plantations near San Juan and Río Piedras, where they were mistaken for the larvæ of the coconut beetle (*Strategus quadrifoveatus*). But it has not been obsaved as a pest of either coconut or cane in the humid section of the Island.

This and the coconut rhinoceros beetle find their natural home in decaying forest trees and stumps, and from such a habitat they have gradually become pests of sugar cane as result of the clearing away of the timber. Perhaps it is the fact that much timber yet remains in the humid sections of the Island that prevents this beetle from becoming a cane pest there The heavier clay soils of these regions may also affect its attack on cane. It prefers timber land to cane fields, as the writer has collected many dozens of the beetles and their grubs in the wooded hills above Santa Rita at a season when very few were being taken in the cane fields.

This beetle has become firmly established as a cane pest in the coast district lying between Aguirre and Fortuna, east of Ponce. There are many records of injury to sugar cane by the grubs in this section. Mr. Van Dine on February 24, 1912, in some cane fields at Central Aguirre found 48 grubs dug from 7 *cepas* (stools), an average of 7 grubs to the stool—enough to cause serious injury to the cane, in view of the immense voracity of these large grubs. Conditions very similar to this have been found to exist at Hacienda Florida, near Santa Isabel, at Hacienda Amelia, Central Fortuna, and also in the Island of Vieques.

In Vieques during periods of drouth, damage from the grubs of *Phyllophaga*, as result of their trimming the roots, becomes accentuated, and the same drouthy conditions also drive the May-beetle grubs deeper into the soil, so that when the cane stool is pulled up and examined, only the large *Strategus titanus* grubs are encountered, and they are naturally blamed for the injury. In a careful examination of many stools of cane an average of 29 grubs and pu-

PLATE 1.—Fig. 1.—Fully grown third-instar grub of *Strategus titanus* (2 ×)
Fig. 2.—Third-instar grub of *Strategus titanus* just molted, showing skin of second instar just shed. (1½ ×).
Fig. 3.—Eggs of *Strategus titanus.* (3 ×)
(Note that the heads of the grubs of Fig. 1 and Fig 2 are of approximately the same size)

pæ per 100 square feet were found, of which 25 were of *Phyllophaga* and 4 of *Strategus*.

On the property of the Guánica Central, where many dozens of bushels of white-grubs[1] are collected annually in the cane fields at plowing time by the laborers, the writer has noted that an average of less than five per cent of the grubs belongs to this species. The great majority belong to the real root-trimming species of May-beetle (*Phyllophaga vandinei* Smyth), which causes most of the damage to cane in this region.

PREVIOUS WORK ON THE SPECIES.

The injury to sugar cane caused by the grubs of this species was first recorded in Porto Rico in 1913 by Mr. Van Dine, on pages 42 and 43 of the Third Annual Report of the Station, though the identification was at that time uncertain.

The injury from the species is mentioned by Mr. Jones in an article in the *Journal of Economic Entomology* (Vol. 8, No. 6, Dec., 1914, pp. 461–463), by the writer in the first report of the South Coast Laboratory in the Third Report Bd. Comm. Agr. of P. R., 1913–14, pp. 40–53, also on page 49 of the Fourth Report Bd. Comm. Agr. of P. R., 1914–15, giving the life-cycle from eggs to adult.

DESCRIPTION OF THE ADULT.

This species can be distinguished from *S. quadrifovatus* by its smaller size, less highly polished surface of body, and by the presence of distinct longitudinal rows of punctures on the elytra, which are absent in the larger species. The males may be readily distinguished from those of the other species by the fact that the anterior horn has a tendency to divide at the tip into two short prongs. (Plate 3, Fig. 1.)

LENGTH OF LIFE-CYCLE.

The life-cycle of the sugar-cane rhinoceros beetle covers approximately one year. The minimum egg-to-adult period, among the 44 reared adults, was 271 days, or just 9 months, and the maximum was 429 days, or practically 14 months. The average normal egg-to-adult period for 44 individuals (of which 14 were male, 18 female, and 12 of undetermined sex) reared in tin boxes was 341 days, or practically 11¼ months. The other three-fourths months is about what is normally required as pre-oviposition period; that is, the

[1] See Jour. Dept Agr. of P. R., Vol 1, No 2, page 69

time elapsing from emergence of the adult from the pupa to the laying of the first fertile egg. If we add to the average egg-to-adult period of 341 days (for the 44 reared adults) the average pre-oviposition period of 22 days it gives an average normal life-cycle of 363 days, or almost exactly one year.

As a control on the individual rearings of beetles made in the tin boxes, considerable numbers of them were reared in cages consisting of screened boxes placed over the soil outdoors. In these the beetles were bred "en masse," a few females being introduced at one time and a week or so later all removed. Thus only the date of egg laying and the final date of emergence of the adults could be observed, the immature stages being meanwhile undisturbed. It was found that the average length of time required for passing of all immature stages in such cages did not vary more than a few days from that secured by the rearing of grubs in the tin boxes

The average egg-to-adult period calculated by adding together the average lengths of the three immature stages—egg, three instars of the larva, and pupa—amounts to 354 days, which is in excess of the average period calculated direct from the 44 grubs that reached maturity because it includes the rearings of grubs that became diseased with *Metarrhizium* and *Micrococcus*. It is known that attack by either of these diseases somewhat increases the length of the instar just preceding that in which fatality occurs.

THE EGG STAGE

Description.—The egg of *Strategus titanus* is opaque and pearly white in color, oblong-oval in shape and round in cross-section. Between the date of laying and the date of hatching it swells greatly in size, and becomes more nearly globular When first laid the eggs average 2⅞ mm. to 3mm. in width by 3½ mm. to 3¾ mm. in length. When fully expanded, and just before hatching, the eggs average in size 4 mm. to 4½ mm. in width by 5¼ mm. to 5⅜ mm. in length. (See Plate 1, Fig. 3.)

The average length of the egg stage, calculated from the rearing of 207 eggs, was found to be 17½ days. The minimum length of egg stage was 15 days (in August), the maximum, 19 days (in December).

As is the case with the May-beetles, the rhinoceros beetle lays its eggs singly, in hardened, spherical cells of earth or fiber that are smooth and symmetrical on the inside, and are from two to three times the diameter of the newly deposited egg. The favorite place,

apparently, for depositing of the eggs, is among the chewed-up and torn fiber in which the adult beetle has been tunneling. Often the eggs are laid inside the buried cane stalks which she has hollowed out in her feeding.

THE LARVAL STAGE.

Description.—The larva of this species is an opaque, yellowish-white to bluish-white "white-grub." In mature larvæ the posterior portion of the body is usually quite dark because of the large amount of blackish woody matter or humus which it contains. The grub has six prominent legs, close together on the ventral side just back of the head, and these are not used for crawling, but merely to assist the grub to move about in its subterranean tunnel. The body is bent, the ventral side inward, and is poorly adapted for crawling, though the grub can straighten its body and crawl over the surface of the ground quite rapidly. The head of the grub is dark brown and chitinous, pitted with many punctures and furnished with very strong mandibles for chewing up woody tissue. The white body is sparsely covered with very short, fine, reddish-brown hair, which is quite inconspicuous. On the legs the hair grows slightly longer and thicker, giving them a brownish color. (Plate 1, Figs. 1 and 2.)

The length of the larval stage, calculated from 53 larvæ that passed the period from egg to pupa successfully in confinement, was 303½ days, or practically 10 months. The minimum larval period of these 53 larvæ was 229 days (7½ months); the maximum 391 days (13 months).

In common with other white-grubs, it molts three times during its life before changing to a pupa, and the periods spent between the molts are called larval instars. During the instars the body of the grub grows at a fairly constant rate, at least until nearly full grown, but the head and legs do not increase perceptibly in size. These latter expand at each molt, then remain without growth until the following molt.

First Instar.—The first instar of the grub is the period comprised between the dates of hatching of the egg and the first molt. During this instar the grub makes its greatest growth, though this instar is considerably shorter than either the second or third instars. The average length of the first instar of 115 grubs was 40½ days; the minimum, 24 days; the maximum, 72 days. From the hatching of the grub to the first molt it increases in length from 8 to 25 milimeters. The average width of head of 20 grubs of first instar was 3.54

mm.; the minimum, 3.25 mm.; the maximum, 3.9 mm. The first-instar grub is able to subsist and grow with no more organic matter present than the normal humus in black soil. Toward the end of the instar, however, it begins to devour rotten wood or cane stalks when these are available.

Second instar.—The average length of the second instar of 67 grubs was 72 days, or not quite two and a half months. This is almost double the length of the first instar. The minimum length of time spent in this instar by any grub was 43 days; the maximum, 85 days.

The rate of growth of the grub during the second instar is shown by the following table:

Growth of Second Instar Grub.

Number of grubs averaged	Age of grubs	Average length of body	Average width of head
16	Under 1 week	25¼ mm.	5 64 mm.
34	1 to 5 weeks	32 mm.	5 84 mm.
36	5 to 9 weeks	40¾ mm.	6.07 mm.
5	Over 9 weeks	45 mm.	6.24 mm.

Third Instar.—It is during the third instar that the grub makes its most astonishing growth. However, all of this growth is accomplished during the first two or three months. During the remaining three to four months, preceding pupation, the grub grows very little, though there is an increase in weight due to the constant building up of fatty tissues in its body. (Plate 1, Figs. 1 and 2.)

The average length of the third instar, calculated from 55 grubs, was 199 days, or 6½ months. The minimum length of third instar for any grub was 137 days (4½ months); the maximum, 282 days (9¼ months).

FEEDING HABITS OF THE LARVA.

The sugar-cane rhinoceros beetle has acquired the habit of attacking sugar cane within comparatively recent years. In the dense woody growth of the base of a large cane plant the larvæ find conditions favorable to their development, and the adult finds an abundance of food material in the living cane stems.

The grubs show a strong preference for the rotted stems in the cane stool, and do not ordinarily attack the living stems. However, when the grubs are abundant, the portions of dead stem remaining in the stool from a previous ratooning may be entirely consumed by

them before they reach maturity, and in that case they do not hesitate to attack the underground portions of the living stems. Grubs have been observed which had entirely severed growing cane stalks underground, and then tunneled upward within the stalk, sometimes for a distance of several inches, and pupæ have been found within the tunneled base of the stalk underground.

The grubs of this beetle show a preference for rotting wood, and are most frequently encountered about stumps in the fields, at the bases of fence posts, and in piles of stable manure.

THE PREPUPAL STAGE.

When the rhinoceros grub has reached maturity it ceases feeding and proceeds to make, out of the fiber and soil surrounding it, a smooth oblong cell in which it can pupate; that is, transform to the dormant, resting condition, which is called the pupa. The pupal cell is oblong, two or three times the length of the pupa, and not quite double its width. It is usually made near where the grub ceases feeding.

The mature grub becomes inactive or even very sluggish for some days or weeks before pupation. The first symptom of approach of the pupal period is a slight yellowing of the grub in color, the skin becomes flabby and wrinkled, and the grub feels soft to the touch where formerly it was firm. The grub lies on its back, with the head and caudal part of the body bent upward sharply, not in a rounded curve as formerly. The legs are drawn close together and held upward stiffly. The grub is motionless and does not move even when touched. It remains in this condition for a period almost equal to the pupal stage.

During the prepupal stage the larva is especially susceptible to the attack of fungus or bacterium, or of such pests as mites and nematodes.

THE PUPAL STAGE.

At the end of the prepupal stage the larva sheds its skin and changes to a pupa, or nymph, which is at first white but changes to brown within a few hours. (See Plate 2, Fig. 1.) The pupa lies motionless in the cell, except that it turns over occasionally and lies with ventral side down at intervals. The legs of the adult are clearly indicated on the pupa, but end in rounded knobs where the feet are to form.

The length of the pupal stage averages 24 days ($3\frac{1}{2}$ weeks). The minimum pupal period was 22 days; the maximum 29 days.

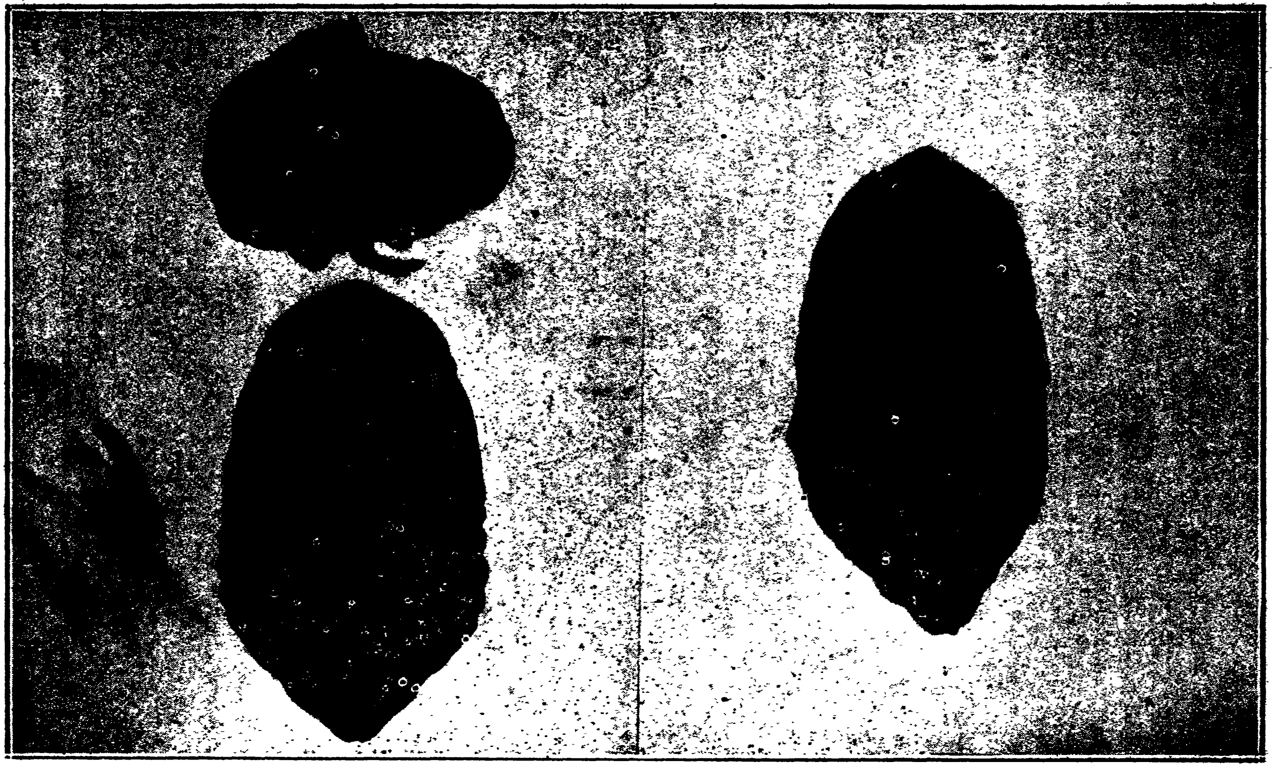

PLATE 2.—Fig. 1.—Pupa of *Stratægus titanus*, with shed skin of thid-instar grub above. (2 ×).
Fig. 2.—Pupa of *Stratægus titanus* killed by the fungus *Metarrhizium anisopliæ*. (2 ×).

EMERGENCE OF THE ADULT.

The adult is entirely white in color when first emerging from the pupal skin. The head and thorax and the legs are the first to turn brown, the elytra turning more slowly, requiring several days before they have reached complete hardness.

Since rhinoceros beetles do not burrow deeply in the soils to pupate, as do the May-beetles, heavy rains to soften the soil are not necessary before they can emerge from the pupal cell. They become active within a week after issuing from the pupa, and at once dig their way to the open. This means that while the egg-to-adult period of the *Strategus titanus* averages 11 months as compared with 9 months for the same period in the sugar-cane May-beetle (*Phyllophaga vandinci* Smyth), the period spent in the pupal cell after issuing from the pupa is so much shorter than in *Phyllophaga* that the complete life-cycle differs very little from that of the May-beetle.

FEEDING HABITS OF ADULTS.

Unlike the adult May-beetles, the rhinoceros beetles do not feed upon foliage. Their food consists largely of the green parts of woody plants and young trees, and perhaps to some extent of the rotted wood or other material which the larva eats. They rarely destroy cane, as is the case with the coconut rhinoceros beetle, and this is only incidental to their penetration into the cane stool to lay their eggs. Injury to the buds of cane supposed to be caused by this beetle has been called to the attention of the writer, but most often such work is due to the hard backs, *Ligyrus* or *Dyscinetus*.

HABITS OF FLIGHT.

The adults of *Strategus* are very strong fliers, and cover a considerably larger range of territory in their flight than do the May-beetles. However, because of their very different feeding habits, the beetles do not come forth nightly to take flight, but may occasionally remain a number of days in their burrows in the cane stool, or in a rotten stump. The females fly less often than the males, and the presence of one or more females in a cane stool may cause the gathering of a number of males, new ones arriving each night. This habit of the males gathering where females are present has been observed in the case of a screened cage in which the beetles were being reared from manure.

The beetles fly with a heavy buzzing sound, very fast in the ear-

lier hour of dusk, but slower as darkness approaches and closer to the ground, in search of suitable breeding places.

Adults of both sexes come to light, and have been collected during almost every month of the year, but most commonly between April and September. They never come in large numbers to light, and the collection of a dozen individuals in a whole summer, even at strong light, is exceptional. The use of light traps as a means of control gives no promise of success.

COPULATION.

Copulation of the adult beetles may take place at any time, and usually within the concealment of the beetle's burrow. The male beetles exhibit great strength and endurance. They are exceedingly amorous, and will engage in long combat with any other male that approaches a female. At such times the horns are used to best advantage, and the possessor of the larger horn, which is also in every case the larger beetle, is the victor, and sends its adversary rolling time after time.

As the male approaches its mate it produces a loud squeaking noise that may be heard for a long time after the beetle enters the burrow and passes out of sight.

PRE-OVIPOSITION PERIOD.

The length of the pre-oviposition period for this species, the average of 5 females, was 24 days, the minimum being 20 days and the maximum 27 days. When added to the egg-to-adult period of 431 days, this makes a total life-cycle for the species of exactly one year.

A freshly issued pair of beetles confined together on September 1st was observed in coitu on September 18th, and the first egg was laid September 28–30.

OVIPOSITION.

The average length of life for 11 females confined to observe oviposition was 37½ days (5 weeks), and the maximum 93 days (3 months). The average number of eggs per female was 13, the maximum number 43. The average estimated length of oviposition period was 8 days, the maximum 21 days, the minimum 1 day. Usually oviposition was continuous from the day that it began, but in 3 cases it was interrupted by short periods of a few days, during which time there was no egg-laying.

In a recent number of THE JOURNAL OF THE PORTO RICO DEPARTMENT OF AGRICULTURE,[1] page 141, the writer has recorded briefly the natural enemies of the two species of rhinoceros beetle occurring on the Island. Among these, the mongoose is very probably the most important. As a result of studies made by Mr. C. B. Williams, in Trinidad, it has been shown that beetles, particularly *Sacrabacidæ*, constitute a portion of the food of this animal, which enjoys such bad repute in all the islands into which it has been introduced, due to its attacks on poultry and the native birds.

The Porto Rican blackbird (*Holoquiscalus brachipterus*) is most efficient in destroying the larvæ when they are turned up by the plow, particularly the immature larvæ. The writer has seen several of these birds attack and eat a full-grown grub of this species.

The rhinoceros beetle has no insect enemies.

There are at least two species of mites commonly found on the adult beetles. One of these is sluggish and does not move about over the body of beetles. It is doubtless a fungous-inhabiting mite that uses the beetle merely as a means of transportation. The other mite, however, is a true parasite of the beetle and may be found upon it in all stages. It runs about very actively among the hairs over the beetle and gathers in numbers along the sutures on the underside to feed The immature stages are pale, yellowish white, while the mature mites are brown. When a beetle dies, the mites at once leave it and crawl about the soil very actively, at once attaching to any living *Strategus* they may encounter. The mature mite is over a millimeter in diameter—quite large for a beetle parasite. The species has not been determined.

Another mite, of very different form, is apparently parasitic on the eggs of *Strategus*. This is a very slow-moving and sluggish mite, seven-eighths mm. to 1 mm. in diameter, pearly white with brown markings, rather thick and of a truncated oval shape. It is an inhabitant of the egg cavities made by the *Strategus* beetle during oviposition and feeds upon the egg, ultimately causing its death. The mite has not been determined.

The grubs in confinement are subject to a bacterial disease which produces shining black hardened areas on the body, legs or head, which often spread so as to result in the death of the grub. This disease is caused by the bacterium *Micrococcus nigrofaciens*, which also attacks the smaller May-beetle grubs. No diseased grubs have

[1] List of Insect and Mite Pests of Sugar Cane in Porto Rico.

been collected in the field, but grubs which were healthy when collected often become diseased in confinement.

The green muscardine (*Metarrhizium anisopliæ*), is extremely virulent in its attack upon this beetle, both in the adult and the immature stages. The stage most susceptible to attack seems to be the pupa (Plate 2, Fig. 2.); that least susceptible, the egg.

The first green muscardine was found in Porto Rico when Mr. Van Dine noted a grub of this species attacked by it on Hacienda Florida, at Santa Isabel, on February 1, 1913. The diseased grub was referred to Mr. J. R. Johnston, the pathologist of the Station, and the fungus determined as *Metarrhirium anisopliæ*. On May 6 and 7 Mr. Jones visited the field and made a thorough examination of the soil surrounding 44 stools of cane, and found, of 8 larvæ, 2 pupæ and 6 adults of this species collected, that 4 larvæ (50 per cent) and 2 pupæ (100 per cent) were diseased with *Metarrhizium*. Among the number of *Strategus* grubs which he brought back to Río Piedras to rear, the disease had developed by July 3d in 2 more larvæ.

CONTROL.

Use Correct Planting System.—One thing which greatly encourages the attack of grubs of this beetle as well as other white-grubs, in sugar-cane plantations, is the method of planting cane by which the new furrow is broken midway between the two old furrows, when cane is to be replanted and all the old rattoon stubble left in the field, undisturbed. Not only are all grubs or pupæ in the cane stools allowed to mature, but if there are young stages present below the third instar, which have most of the feeding to do yet, these merely migrate from the stubble to the new plant cane and begin feeding on it. In all circumstances the old cane should be plowed open down the row, and the grubs thus exposed gathered and destroyed.

Avoid Excess of Organic Matter.—As *Strategus* grubs feed entirely upon organic matter, the addition of stable manure, filter-press cake, bagasse, or any other organic fertilizer should be avoided in any fields or parts of fields subject to attack of rhinoceros beetle grubs. Even an excess of dead cane stubble and dry stalks should be avoided by piling and burning these after the plowing.

Use of Poison Bait.—Grubs of the rhinoceros beetle may be very successfully poisoned by means of a poison bait consisting of some organic fertilizer, palatable to them, to which has been added a small amount of some arsenical. Stable manure, bagasse or filter-

press cake that has been broken up fine may be used. The arsenical poison should be stirred thoroughly into a large bucket of water, and this is then sprinkled over the organic fertilizer by means of a sprinkling can. Two pounds of white arsenic (arsenic trioxide) or Paris green, or four to five pounds of lead arsenate, calcium arsenate or zinc arsenate may be used to each hundred pounds of manure, bagasse or *cachaza*. The poison bait thus made may be thrown in small handfulls around the newly planted cane before it is covered, or may be thrown broadcast in the field before the final plowing. Or it may be thrown about the stools and covered with trash. The grubs eat it and are killed in large numbers. This control method serves also for protection against hard-backs, but does not have any effect on the root-trimming grubs of the May-beetle. Pen manure lying in piles near the cattle pens can be poisoned in the same way and many grubs killed.

Manure Trap Piles.—Where there are local sections of cane fields attacked by these grubs, it is possible to attract the beetles and grubs in large numbers by placing manure heaps at intervals along the border of cane fields. At regular intervals of once a month or once in two months these should be spaded over carefully and all the grubs and beetles found in them destroyed. However, if such piles are abandoned and not visited regularly and the grubs destroyed, they become a menace rather than a benefit because of the large number of beetles that mature in them

THE COCONUT RHINOCEROS BEETLE.

Strategus quadrifoveatus Beauv.

This beetle secures its name from its habit of damaging the coconut palm. As a pest of sugar cane it is of small importance, although the adults have been taken a number of times injuring cane. A few such instances have been recorded by the writer[1] in previous publications of this Station.

As a pest of the coconut palm this insect is possibly responsible for more injury than is generally noted, because coconut plantations, once set out, are usually not further cared for until they mature, so that the occasional loss of a few trees in the midst of hundreds of acres of them is not looked upon generally with concern.

[1] Third Rept. of the Board Comm. of Agr., page 44, Fourth Report, page 49, and Ann. Rept. for 1917–1918, page 128.

LATE 3.—Fig. 1.—Male adult of *Stratægus titanus*, showing anterior thoracic horn divided at tip. (2 ×).
Fig. 2.—Underside of female adult of *Stratægus titanus* killed by the fungus *Metarrhizium anisopliæ*. (2 ×).

DISTRIBUTION AND HABITAT.

This species has been recorded from Santo Domingo and Haiti, in addition to Porto Rico. The mature larvæ have been found in rotten stumps at Higueral, Santo Domingo, near La Romana, but no adults. In Porto Rico the species is very common, and is distributed over the entire Island. It doubtless occurs also in Vieques, Culebra and Mona Islands.

The insect differs from the preceding species in that the grubs have not acquired the habit of attacking sugar cane, and attempts to rear them in confinement on any other material than rotting wood cr coconut fiber have resulted in failure.

Only the adults injure sugar cane, and usually several are found in one stool while no other stool near by is attacked. The males always predominate, and very often there is but a single female present among a half dozen or more males taken from one stool. It seems probable that the female alights among the cane and that the males are attracted to her. Having lit in the cane, the beetles bore into the base of the stalk for the succulent juice. The beetles enter near the ground and bore upward, sometimes excavating a tunnel eight inches to a foot or more in length. The cane, weakened by the large size of the excavation in it, is soon blown over by the wind. The work is so conspicuous as to always command the attention of any worker in the field, and to cause some apprehension. Yet in no case have more than one or two stools been attacked on a single plantation in an entire season, so that the injury is insignificant in extent compared with that caused by the grub of the sugar-cane rhinoceros beetle.

It is in the coconut plantation that this beetle causes its great damage, and this will be described later.

PREVIOUS WORK ON THE SPECIES.

The writer first published a brief note on the injury to sugarcane by this species in the Third Report of the Board of Commissioners of Agriculture, page 44. The species was not accurately determined until the following year, when another note on the injury caused by the adults to cane was published (Fourth Report of the Board, page 49), and the life-cycle of the species was given (page 47). On pages 123 and 124 of the Annual Report of the Station for 1917–1918 the writer gives a short account of the beetle and its injury.

This species is also treated briefly in a recent number of this JOURNAL,[1] along with *Strategus titanus* and other cane pests.

DESCRIPTION OF ADULT.

The adult of the coconut beetle may be at once separated from that of the sugar-cane rhinoceros beetle by its much larger size and more highly glossed surface, and by the absence of the longitudinal rows of punctures present in the smaller species. In the male of this species, the anterior horn is never divided at the tip, where in the other species it shows a strong tendency to divide into two short prongs. (Plate 4, Figs. 1 and 2.)

LIFE-HISTORY WORK.

Unfortunately, a much smaller number of this insect has been successfully reared through all the instars to the adult than is the case with *S. titanus*. This is due partly to the greater difficulty experienced in rearing these grubs, as they refuse any food but rotted wood or coconut fiber, and do not thrive well on the latter. Even the rotted wood must be of proper consistency to be acceptable to the grub.

LENGTH OF LIFE-CYCLE.

For two individuals which were reared from egg to adult, the average egg-to-adult period was 430 days (14 months)

The pre-oviposition period was not determined, as neither of the two reared adults was kept alive for the eggs However, if the pre-oviposition perior is the same as that for *S titanus,* 24 days, this added to the egg-to-adult period of 430 days makes a total life-cycle of 454 days (or 15 months). This is probably somewhat in excess of the average for the species.

THE EGG STAGE.

Description.—The egg of this beetle is similar in appearance to that of *S. titanus,* but somewhat larger in size. When first laid it varies from 3.1 mm. to 4 mm. in length by 3 mm. to 3.35 mm. in width. When fully expanded and shortly before hatching it varies from 5 mm. to 5.2 mm. in length by 4.5 mm. to 4.6 mm. in width.

The average length of the age stage was found to be 20 days, the minimum 17 days, the maximum 22 days.

[1] The Insect and Mite Pests of Sugar Cane in Porto Rico, Jour P R Dept Agr, Vol III, No 4, p 141.

The larva of this species differs from that of the preceding mainly by its larger size and by the broader head. In fact, the head of the grub is enough larger than that of *S. titanus* to make it possible to distinguish it readily from the other in any of the instars by measuring the head. The average length of the larval period for this species was 383 days (12½ months).

First Instar.—The average length of the first instar of this species, from a rearing of 8 grubs, was 39 days. During this instar the grubs increase from 10 mm. to 28 mm. in length, and the width of the head varies from 3.4 mm. to 3.6 mm.

Second Instar.—The length of this instar, calculated from the rearings of 9 grubs, was 71 days. As a result of the rapid growth of the larva that takes place during the second instar, it increases in length from about 28 mm to 55 mm. before molting to third instar. The head varies in size from 6.6 mm. to 7.3 mm.

Third Instar.—The last larval instar, according to the breeding experiments, covers the very long period of nine months. Whether the larval period of the two individuals that were successfully reared to adults in confinement was unduly prolonged as a result of the artificial conditions of their environment, or whether they represent the normal period for the species, can only be determined after additional rearing work with the insect. There seems no reason to believe that the confinement of the grubs lengthened or otherwise altered the larval period in the case of this species when it did not do so with the other *Strategus.*

The average length of the third instar, calculated from two grubs, was 275 days. During this instar the grub increases in length from about 50 mm. to 85 mm., and the head varies from 11.5 mm. to 12.5 mm. in width (being from 1 to 2 millimeters wider than that of *S. titanus.*)

The heads of grubs, presumably of this species, collected in rotten palm trees in Santo Domingo by G. N. Wolcott, measured in width: first instar, 3.5–3.7 mm.; second instar, 7.5 mm.; third instar, 14.3 mm.

FEEDING HABITS OF LARVA.

This grub thrives only upon decayed wood and partly rotted coconut fiber, and refuses to feed upon manure or other organic fertilizer. It is never encountered in the cane fields except around the bases of old stumps.

In one experiment made by the writer a dozen adults of this

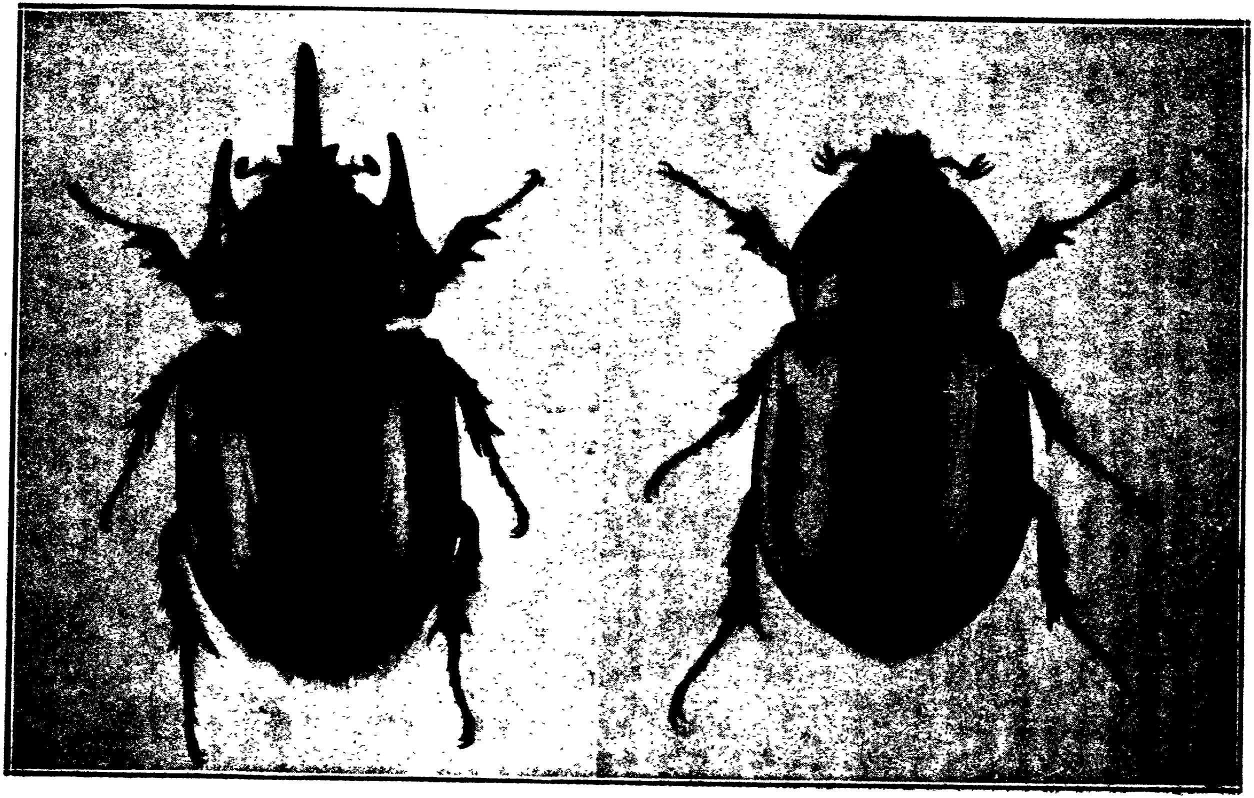

PLATE 4.—Fig. 1.—Male adult of ***Stratægus quadrifoveatus*** **($1\frac{1}{3}\times$).**
Fig. 2.—Female adult of ***Stratægus quadrifoveatus.*** **($1\frac{1}{3}\times$).**

beetle, of both sexes, were put into a large screened rearing cage, three feet square and six feet high, which covered a large stool of half-grown cane planted in the field. Within two weeks the beetles had bored extensively into the bases of two stalks of cane, killing both, and had injured other stalks at their bases.

Two months later the cage was removed and the cane stool and soils dug up and examined to a depth of a foot. The beetles were all dead and had decayed, and if eggs had been laid, there were at least no sign of grubs in the soil. This demonstrated that eggs deposited in such material do not mature, or that the grubs of this insect cannot live upon cane stalks or stubble.

THE PRE-PUPAL AND PUPAL STAGES.

The descriptions of the pre-pupal and pupal stages of *S. titanus* apply equally well to *S. quadrifoveatus*. The average length of the pupal stage (for 2 pupæ) was 27 days.

In size, the pupa as a fourth larger.

FEEDING HABITS OF THE ADULT.

The adult eats the succulent tissue of woody plants and trees, into which it bores by means of its powerful barbed legs and mandibles. It is remarkable how these beetles can tear their way into the tough, woody stem of a living coconut palm, or a mature cane tsalk. So powerful is the beetle that it is almost impossible to hold one in the naked palm without suffering lacerations of the skin.

This beetle differs from the true rhinoceros beetle of Samoa (*Oryctes rhinoceros*) in that it does not enter the stem of a coconut palm high up among the leaves, as does that insect. It does, however, very often bore into half-grown to mature coconut palms at the level of the ground, even though the palm is thriving and healthy. The writer has seen, near Río Piedras, several coco palms of large size blown over by the wind, during a hurricane, that showed extensive cavities at their base. The cavities are doubtless made in all cases by the beetle and never by the grub. In no case have the larvæ been found in these cavities in living palms.

The greatest damage to palms from this beetle does not come from its boring into mature or half-grown trees, but from its havoc to trees under two years old by boring upward, from the central tissue of the young palm. Much trouble from this source has been experienced by all coconut plantation owners, and some of them replant yearly from one to five per cent of all nursery trees from this cause. One beetle is sufficient to kill a young palm in a single

night, though it does not usually leave the same palm for some days. In a season's time, however, one beetle may kill a dozen or more palms. For this reason, each beetle that is caught and killed early in the season may mean the saving of several young trees; and realizing this, the plantation owners set boys to work catching them as soon as the flight begins, and pay as high as five cents per beetle.

FLIGHT AND COPULATION.

These have been described for the preceding species, and the habits of the adults of the two species, as regards time and nature of flight, copulation, etc., are very similar, and differ only in the matter of feeding habits.

OVIPOSITION.

The pre-oviposition period of this beetle has not been determined by experiment, but probably exceeds that of *S. titanus* by a few days.

NATURAL ENEMIES.

These are the same as for *S. titanus*, and have been discussed under that species.

Some mites, determined by Dr. H. E. Ewing as *Tyrogryphus heteromorphus* Felt, were found on grubs collected in rotten palm trees in Santo Domingo by G. N. Wolcott. This mite is a fairly common species in the United States and has been reported as injuring the roots of carnations in Massachusetts, but its food habits have not been extensively studied.

CONTROL.

As a cane pest, this beetle is of slight importance and the control need scarcely be considered. As a coconut pest, however, the insect is a real menace, and it behooves any owner of a young coconut plantation to take active steps to reduce the number of the beetles.

Prevention of Attack.—Several methods of protecting the young palms against attack of the beetles have been suggested, but the author has not had opportunity to try out any of these on a large scale. Mr. S. V. Lippitt claims to have obtained complete protection of his young plants by putting plenty of rock salt around each tree.

If it is true that the rotting coconut husk of the germinating nut first attracts the beetles as a place to lay its eggs, and that from

this from this it bores upward into the fleshy center of the young tree to secure food, then it may be possible that the treatment of the nut and husk, before planting, with some very strong repellent such as carbolinium or crude petroleum, would protect the young tree from the attack of the beetle until it had reached sufficient size to escape danger.

Catching the Beetles.—A very safe, sure, and inexpensive way to get rid of the beetles is to have them collected by small boys provided with hand nets similar to butterfly nets, but made of stronger material. As the beetles fly through the coconut grove at dusk they may be captured by a boy provided with such a net. Each beetle captured means not only the saving of one or several young coco palms, but also a decrease in numbers in the next generation of beetles. The beetles should be killed and not allowed to escape, as was done on one coconut plantation visited by the writer.

Removal of Breeding Places.—The larvæ of this beetle breed only in decayed or rotting wood logs and stumps. Such material should be collected into piles and burned. Or it should be accumulated into piles and then turned over and examined at intervals once a month or once in two months, and all grubs found in it collected and destroyed, or fed to hogs. The number of large grubs that may be gathered in this manner will astonish the average coconut grower, if he has them collected.

If the old wood and rubbish in a plantation is gathered into piles, but no attempt made to destroy it nor to have it turned over and examined regularly for the grubs, it becomes more of a menace than when scattered about the grove, and becomes a favorable breeding place for the grubs, from which beetles will issue in large numbers every year.

Poisoning Grubs.—While no experiments have been made in order to test the practicability of control by poisoning, it is possible that the grubs of the rhinoceros beetle may be poisoned successfully. Where the coconut husks are piled about the bases of trees in a plantation, turning over or raking aside of these would be expensive, but by sprinkling them thoroughly with a liberal amount of water in which has been mixed Paris green at the rate of two pounds per hundred gallons they could be made permanently poisonous to the grubs.

PUBLICATIONS OF THE YEAR (1919–1920).

(Published or in Press.)

1. Annual Report of the Insular Experiment Station of the Department of Agriculture and Labor of Porto Rico 1918–19. (E.)
2. The Journal of the Department of Agriculture of Porto Rico, Vol. III, No. 3. The Mottling or Yellow-Stripe Disease of Sugar Cane, by J. A. Stevenson. (E.)
3. The Journal of the Department of Agriculture of Porto Rico, Vol. III, No. 4. Yellow-Stripe Disease Investigations (Progress Report), by F. S. Earle, C. A. Figueroa, E. D. Colón, F. A. López Domínguez, J. Matz and E. G. Smyth. (E.)
4. The Journal of the Department of Agriculture of Porto Rico, Vol. IV, No. 1. Root-Disease Investigations, by F. S. Earle and J. Matz. (In press.) (E.)
5. The Journal of the Department of Agriculture of Porto Rico, Vol. IV, No. 2. The White Grubs Injuring Sugar Cane in Porto Rico. The Rhinoceros Beetles, by E. G. Smyth. (In press.) (E.)
6. Bulletin No. 19. The Resistance of Cane Varieties to Yellow Stripe or the Mosaic Disease, by F. S. Earle. (E.)
   Boletín No. 19. (Edición española.) La Resistencia de las Variedades de Caña a la enfermedad de las Rayas Amarillas o del Mosaico.
7. Boletín No. 20. Insecticidas y Fungicidas, por I. A. Colón. (S.)
8. Boletín No. 21. Abonos (1918–19), por F. A. López Domínguez y R. Vilá Mayo. (S.)
9. Bulletin No. 22. Eradication as a Means of Control in Sugar-Cane Mosaic or Yellow Stripe (The Year's Experience with the Method), by F. S. Earle.
   Boletín No. 22. (Edición española.) La Extirpación del Mosaico de la Caña como Medio de Represión, por F. S. Earle.
10. Bulletin No. 23. Plant Inspection and Quarantine Report (1918–19), by E. G. Smyth. (In preparation.) (E.)
11. Circular No. 17. Recomendaciones sobre el Cultivo de la Caña en Puerto Rico, por F. S. Earle. (S.)
12. Circular No. 18. Extirpación de la Garrapata, por J. Bagué. (S.)
13. Circular No. 19. La Preparación de Abonos Mezclados por el Agricultor, por F. S. López Domínguez. (S.)
14. Circular No. 20. La Gomosis de la Caña, por J. Matz. (S.)
15. Circular No. 21. El Cólera del Cerdo, por J. Bagué. (S.)
16. Circular No. 22. El Mosaico de la Caña o Matizado, por F. S. Earle. (S.)
17. Circular No. 23. Variedades de Caña, por F. S. Earle. (S.)
18. Circular No. 24. La preparación de la Disolución Arsenical para el Exterminio de la Garrapata, por F. A. López Domínguez. (S.)
19. Circular No. 25. El Mal del Guineo, por J. Matz. (S.)

(E.) means English only.
(S.) means Spanish only.

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AN ANNOTATED LIST OF SUGAR CANE VARIETIES

F. S. EARLE,
EXPERT IN CANE DISEASES.

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AN ANNOTATED LIST OF SUGAR-CANE VARIETIES.

By F. S. EARLE.

The present serious epidemic in Porto Rico of Sugar-Cane Mosaic or Yellow-Stripe Disease, locally known as "Matizado," serves to again call attention to the great importance of a careful study of cane varieties, especially with reference to their resistance or susceptibility to diseases and insect injuries and their ability to adapt themselves to unfavorable cultural conditions. The history of the sugar-cane industry shows numerous instances in different countries where its existence has been seriously threatened by the failure of the variety in general cultivation due to the attack of some disease or pest. In all such cases the industry has been saved by the substitution of other kinds that proved less susceptible to the prevailing trouble. One of the first recorded cases of this kind occurred in Mauritius and Reunion between 1840 and 1850. The exact nature of this trouble cannot now be determined, but it was probably some phase of the complex included under the name of Root Disease.[1] The kind in general cultivation was the Caña Blanca or Otaheite, and its complete and rather sudden failure lead to the searching of all parts of the sugar-cane-growing world for other kinds with which to replace it. Canes were brought to Mauritius from Java and the other East Indies, from Egypt, from the West Indies and from Brazil. The large collection of varieties thus brought together made Mauritius a center of distribution from which all other cane-growing countries have drawn as in one after another the Otaheite cane, so universally planted during the first half of the nineteenth

[1] See Journal Porto Rico Dept. of Agric., Vol. 4, No. 1.

century, gave down under the attack of the various enemies to which it is so susceptible, especially as soils became old and impoverished.

Brazil seems to have been the next country to have suffered from a cane epidemic. About 1860—the exact date cannot be determined—an outbreak of Gum Disease almost completely destroyed the Otaheite, or as it was there called the Cayania cane. It is evident that many varieties were brought to Brazil in the effort to reestablish the sugar industry, since large numbers are known to have existed at the Rio Janeiro Botanical Gardens and at the Experiment Station at Campinas. It has not been possible so far to trace the history of these importations. Collections from Río were sent to the Argentine and also to Northern Brazil and the West Indies, but the varieties mostly seem to have been renamed as the names of these Brazilian kinds are different from those used in Mauritius and Java. The kind now mostly grown in Brazil is the red cane, properly known as Cavengerie, but there called Louzier evidently through some mistake in labeling It seems probable that this Gum Disease was carried from Brazil to Mauritius in an importation known to have been made in 1869 From Mauritius it apparently was carried to Australia, where it was studied by Cobb and has hence come to be known as the Australian Gum Disease. It is now also found in the Hawaiian Islands and it has recently been found in Porto Rico [1]

During the years following 1880 the Java sugar industry was very seriously threatened by the so-called "Sereh Disease," which forced the abandonment of the Black Cheribon cane (Louisiana Purple) which was then extensively grown. This has been more extensively investigated than any other cane disease, but there is none in regard to the nature of which so little is actually known. In seeking to combat it importations were made from all the neighboring islands, from India and from all other available sources. At one time collections of as many as 413 numbers were reported on at the Field Station for East Java. A few of these were duplications, but for the most part they had different names. Coming from so many different sources it is quite certain that there were many more names than actually distinct varieties. It is most unfortunate that no careful taxonomic study of this great collection of named varieties seems to have been made. At least no list of synonyms or other account of such study has been published and the opportunity has been lost, for with the discovery that new cane varieties could be grown from seed all interest in the older kinds seems to have been

[1] See Circular No. 20

suddenly lost and investigators all over the world have turned their attention to the fascinating pastime of originating new seedlings. The fact that the older kinds represented the selection for many generations of the kinds best adapted to their peculiar local environments seems to have been lost sight of, and the tendency has been everywhere evident to discard them on insufficient grounds in favor of new and only partially tested kinds. Notwithstanding the immense amount of attention that has been given to new seedling varieties during the past twenty years and to the undoubted merits of some of these new kinds, the fact remains that by far the largest part of the world's cane sugar is still made from a few of the old, standard, long-tested kinds. It seems a great pity that the opportunity for their further study afforded by these great Java collections was not more fully utilized. Sugar-cane varieties need to be studied from many different points of view. Too much attention has usually been centered on high sucrose content and good milling qualities. Modern mills can grind and extract the sugar from any cane, no matter how hard and intractable it may be, and whether it will be more profitable to plant canes with the highest sucrose content or to look for those yielding the greatest tonnage and ratooning for the greatest number of years, even if of lower grade, will depend on many factors. It is a question of the greatest practical importance that must be decided for every factory according to its local conditions In order to decide it intelligently we need to know in regard to each variety not only its percentage of sucrose and purity when fully mature and in best condition and the probable tonnage to be expected under favorable cultural conditions; but it is even more important to know how it will behave under drouth and neglect, when it matures whether early or late, how long it will remain in good condition in the field after maturity, and above all how it reacts to Root Disease, Gum Disease, Mosaic Disease, borers, root grubs and other pests. We must know, too, whether it is best adapted to heavy or light lands, to wet or dry situations, and consequently how long it may be expected to ratoon under each of these different conditions. Very few of the older varieties have ever been sufficiently tested under such varied conditions as to enable us to intelligently answer all of the above questions. It seems clear that no variety having merit enough to maintain itself for many years in the country of its origin should be definitely discarded until it has been thoroughly tested from all of these points of view.

It is not conceivable that any one variety will be found that is best adapted to all the varying conditions under which cane is grown. We need canes adapted to high dry lands and those able to grow in poorly drained marshes and swamps. We need canes for heavy clay soils and for sandy loams. Even were it possible to find any one kind well adapted to all these varied conditions we would still need early-maturing and late-maturing kinds in order to keep the factory supplied during as long a season as possible with fully matured but undeteriorated canes. One of the greatest weaknesses in the cane-sugar industry has always been too great a dependence on some one favorite variety of cane.

The west coast of Porto Rico suffered from a serious cane epidemic which first attracted attention at Mayagüez in 1872. This lead to the importation of many different kinds and finally to the practical abandonment of the Caña Blanca or Otaheite and the substitution of Rayada, Crystalina and other more resistant kinds. The exact nature of this epidemic has not been determined, though it seems to have been some form of the so-called Root Disease. Further mention of this outbreak and of the varieties imported to combat it will be found in a subsequent paper. Now, in turn, the Rayada and Crystalina have been so severely attacked by cane mosaic or "Matizado" in this same district that the industry is again seriously threatened. It now seems probable that in this district, at least, these kinds must soon give way and be replaced by others capable of resisting this new trouble.[1]

In Barbados and other of the British West Indies there has been a somewhat similar history. The Bourbon or Otaheite cane long ago went down before the ravages of Root Disease and of Rind Disease.[2] It was largely replaced by Crystalina or White Transparent, as it is called in those islands. With increasing soil exhaustion this splendid kind is giving way in turn from the same causes and is being rapidly replaced by some of the new Barbados and Demerara Seedlings.

Australia and Southern India show a somewhat similar history, the Otaheite once the popular favorite being largely replaced by other kinds.

In Hawaii the Otaheite, there known as Lahina, has been mostly discarded on account of Root Disease. Crystalina, there called Rose

[1] See Insular Sta. Bull. No. 19.

[2] Considered by the present writer to be corellated with Root Disease of which it is the final expression. See Jour. Dept. Agric. Porto Rico, Vol. 4, No. 1.

Bamboo, has suffered the same fate, both of these fine high sucrose canes being largely supplanted by the low-grade Yellow Caledonia, which is highly resistant to Root Disease and yields an exceedingly heavy tonnage.

In Natal the entire cane industry is now based on the Uba cane, which has completely replaced the Cheribon and Otaheite canes that were formerly cultivated there. This variety has an interesting history. It is clearly of North Indian origin. In fact, C. A. Barber, the authority on Indian canes, has identified it with one of the Ganna canes which are still grown in that country. It evidently went to Brazil in that early importation of varieties whose history seems to have been lost, for it was included in the lot of canes sent from Brazil to Mauritius in 1869, the only comment on it there being "a worthless cane." From Mauritius it was carried to both Australia and Natal, but it only attracted attention in the latter country, where it now furnishes the raw material for making more than 100,000 tons of sugar per year. The history of this interesting kind does not end here. From Brazil it also went to the Argentine, this time under the name of Kavangire, and from the Argentine a few cuttings came to Porto Rico some years ago. Proving to be completely immune to the Mosaic Disease[1] and to be capable of yielding heavy tonnage on old, compacted lands where other kinds failed from Root Disease, it has attracted much attention and it seems probable that it will soon replace the Rayada in the worst infected districts of western Porto Rico. During the past summer the Federal Department of Agriculture at Washington secured ten tons of seed of this kind in the Argentine and sent it to Porto Rico in the effort to aid in combatting the cane Mosaic.

Finally, in the Argentine it was found a few years ago that the Cheribon canes, Morada and Rayada, which had long been the ones in general cultivation, had suddenly "deteriorated." They have been quite completely replaced by two of the cross-bred seedlings produced by Kobus in Java in his successful attempt to breed varieties immune to the Sereh Disease. These kinds, 36 P. O. J., and 213 P. O. J., are both hybrids between the North Indian cane, Chunnee and the Purple Cheribon. Here in Porto Rico these kinds, also received from the Argentine, while in no sense immune to the Mosaic Disease have proved to be very resistant to its attacks and make full yields, even when completely infected. It now transpires that the sudden degeneration of the Cheribon canes was caused

[1] See Insular Sta. Bull. 19.

by an unnoted epidemic of Mosaic Disease which has been successfully overcome by substituting these resistant kinds.

This brief review of these various sugar-cane epidemics and of their control by the substitution of varieties better adapted to existing conditions and better able to contend with prevailing pests and diseases will serve to emphasize the great practical importance of a knowledge of cane varieties and of their behavior under all possible cultural conditions. It will also serve to explain the reason for the appearance of this publication and to justify the use of the very considerable amount of time given to its preparation.

Besides the large collections of cane varieties already noted as existing in Brazil, Mauritius and Java, others have at various times been found in Louisiana, Jamaica, Trinidad, Demerara, Natal, the Botanical Gardens of Calcutta and Singapore, in Australia particularly at the Brisbane Botanical Garden, in Hawaii and in the Argentine at the Tucuman Station. Various lists have been published by different institutions in these countries, and the total number of varietal names thus used is very large. It seems remarkable that so few attempts have been made to study these collections comparatively and to determine authoritatively the hosts of synonyms that undoubtedly exist among these numerous names. Some attempts have been made in this direction, notably by Stubbs in Louisiana and by Harrison and Jenman in Demerara, but it is to Mr. Noel Deerr that we owe most of our present knowledge of sugar-cane synonymy and the early history of the more important commercial varieties. His wide experience in Demerara, Mauritius, Hawaii and Cuba has given him an unusual opportunity to study cane varieties in the field, and to this he has added a thorough study of the literature. In a paper entitled, "A Brief Sketch of Discovery and Invention in the Sugar Industry," published in the *International Sugar Journal* for 1919, he has given so complete and succinct an account of the early history of cane varieties that it is here reprinted in full since no abridgement seems possible:

"The first mention that I have found of cane varieties is in *Rumph's Herbarium Amboinense*, 1741–53, the material for which was, however, collected at the end of the seventeenth and early in the eighteenth century. He records the existence in Java of three varieties; one white, one red and one striped. He describes the white variety as a soft cane with long joints and affording a copious and sweet juice. The striped variety is described as very slender and long jointed and because of its sweet and plentiful juice cultivated by the Japanese near Soerabaya. The red variety is considered as inferior, being hard, with short joints, and affording a juice inferior in quality and quantity.

"Two further observations of Rumph may also be placed on record. He remarks that whereas in the new world canes could be ratooned up to fifty years, in Java only three crops were possible. He also states that it is necessary to cut the cane before it arrows to avoid loss of juice, an idea which is still prevalent.

"The next mention of varieties is due to the Portoguese Jesuit Loureiro, who published in 1790 a detailed Flora of Cochin China. He mentions a red and white cane and also the 'Elephant' cane of great size in which sporadic interest has from time to time been taken.

"It appears probable that the European industry which survived to the end of the fifteenth century was confined to but one variety of cane which had traveled west from India. This variety in the New World eventually became known as the Creole and still survives, though not under extensive cultivation. The first recorded introduction of a new variety is that due to Bougainville, who is credited with bringing a cane from Otaheite to Mauritius in 1767. The earliest statement the writer has found to this effect appears in Humbolt's 'Journey to the Equinoctial Regions of South America.' He obtained his information in Cuba about 1800. There is, however, no mention of this introduction in Bougainville's own account of his circumnavigation.

"In 1782 Cossigny caused to be introduced from Java to Mauritius a number of varieties, prominent amongst which was a purple cane. These he cultivated in his own garden and distributed locally in 1789. Through his influence the French Government transported these to Martinique, Guadeloupe and Cayenne, at the same time introducing the cane brought to Mauritius by Bougainville. The dates of these introductions are fixed by a letter of Cossigny recorded in Legiers monumental 'Histoire des Origines de la Fabrication de Sucre en France et Aux Colonies.' From Martinique Bougainville's cane was first introduced to Montserrat, the cuttings being afforded by a French planter, Pinel. The principal introduction of this cane to the British West Indies is, however, due to Admiral Sir John Laforey, who at this time possessed a sugar plantation in Antigua. His own account of the introduction is given in preference to the fifth edition of Bryan Edwards' 'History of the West Indies.' In that account he records the similarity, the confusion, and possible identity of this cane with the one introduced by Captain Bligh in 1793 (v. inf.). He mentions also the belief amongst French planters that Bougainville's cane had arrived originally from the rather indefinite locality of the Malabar coast. In January, 1793, Captain Bligh arrived off St. Vincent in the ship *Providence*, bringing with him breadfruit, canes, and other products of the South Seas. The real end of his voyage was Jamaica where the results of his journey were landed and grown (under the care of a gardener, probably Wouels, who had accompanied him) in the East Botanical Garden, lately willed to the Island of Jamaica by a planter of that name. At least four varieties of cane were brought, a green cane with staggered joints and prominent eyes, a violet cane, a violet-and-yellow ribbon cane, and a yellow cane which soon became known as the Otaheite cane. The first two varieties seem to have been lost, but the writer has not infrequently seen canes as strays amongst extended cultivation corresponding to that illustrated by Tussac who also records the decided opinion of Wouels, who had been in Otaheite, that Bougainville's cane, which had already become known as Bourbon, was identical with that commonly grown in Otaheite.

"After their introduction these canes spread rapidly over the West Indies, the dates of their introduction being as follows: Barbados, by Firebrace, 1796; Cuba, by Arango, 1795; Trinidad, by Begorrat, 1792; Demerara, 1796; Louisiana, 1797. From Cayenne the cane in question went at an early date to Brazil, where it is still known as Cayenne cane. It was not till 1840 that this variety reached Mexico, where it was introduced by Hermenegildo Félix.

"It is highly probable that separate introductions of Bougainville's and of the Otaheite cane were made, and it is impossible that the two strains, if not identical, did not become mixed in cultivation. The term "Bourbon," which has survived in British Guiana and in the British West Indies, does not appear in the literature generally much before 1840, and elsewhere the term 'Otaheite' or 'Blanca de Otaheite' is used. At the time the introduction was regarded as of first-rate importance, as indeed it was, and this cane contributed very largely to the well-being of the West Indies during the period of their greatest prosperity. The return of sugar was stated to be increased one-third, and the value of land went up in proportion. From the West Indies this cane travelled to Java, reaching there before 1820 (Crawfurd, 'History of the Indian Archipielago'), and it was successfully grown there for a term of years. From Mauritius it was introduced to British India by Captain Sleeman in March, 1827, and was grown first at Jubbulpore and distributed widely in India. The *Journal* and the *Transactions of the Agricultural and Horticultural Society of India* of this time contain many references to this cane, one experiment recording a return of over six tons of sugar per acre, notwithstanding the sub-tropical climate of India does not seem to have suffered this cane to survive there. This variety also reached the Philippines, where it was established to the exclusion of other varieties in the Island of Luzón (Gutiérrez, 'Memoria Sobre el Cultivo, Beneficio y Comercio de Azúcar,' Manila, 1878).

"Before leaving this cane its history may be concluded by mentioning its introduction into Hawaii at Lahaina (whence the name) in the ship *George Washington*, Captain Pardon Edwards, in 1854, and its rediscovery as a sprout from a striped cane in Mauritius about 1820 by Louzier.

"Contemporary literature seems to identify the canes originally brought from Java by Cossigny as those which have become known since as the White Transparent (Crystalina in Latin America), Purple Transparent (Morada in Latin America), and Red Ribbon (originally Transparent) or Rayada in Latin America. In the early part of the nineteenth century the Otaheite cane and the White Transparent maintained a vigorous competition. In Cuba and in Jamaica the latter survived as the fittest, and in Cuba now is the only variety in extended cultivation. Numerous reefrences in the literature of the early part of the nineteenth century describe their characteristics as follows: The Otaheite is the superior cane, both in field and factory, but requires more careful cultivation and is more readily affected by untoward climatic conditions. The White Transparent is also spoken of as succeeding in soils where the Otaheite would not give a thrifty growth. These are the very reasons which would tend to make the White Transparent or Crystalina a suitable cane for Cuban conditions.

"Introductions of these canes to the West Indies by the Dutch about 1780 are on record. They reached Louisiana through the agency of Coiron in 1825. In 1850 they were again introduced to Mauritius by Sir William Gomm after the Jauene de Otaheite had suffered from an epidemic. In this instance the purple cane became extensively established at Belouguet, it being observed that

purple canes were immune from the prevailing sickness. This introduction is of special interest as forming one of the many links of evidence collected by Darwin in establishing his principles. It is also of interest to note that at the very time that this purple cane was being established at Mauritius, it was also being brought into cultivation in its original home by Gonsalves. There it eventually became known as the Cheribon cane and continued the dominant variety till attacked by the 'Sereh' Disease about 1880. This circumstance lead to the introduction into Java of many varieties.

"Records of many other introductions and exchanges may be found in this literature, and the planters of Mauritius seem to have been particularly active in this direction. Of these later introductions there may be recorded that of the Uba cane from Brazil to Mauritius in 1869, and probably thence to Natal and Mozambique; of the Tanna canes from Australasia to Mauritius probably about 1870; and as Yellow Caledonia to Hawaii by W. G. Irwin in 1885. The latest introduction of canes is that of the New Guinea varieties, Badilla, and the Gorus to Australia by W. Maxwell about 1905."

The reading of the above interesting historical notes by Mr. Deerr at once shows the early and continued importance of the little island of Mauritius as a distributing center for cane varieties. With the single exception of the old original Creole cane all the commercial kinds of importance seem to have reached the Western World through this gateway. It may be interesting to add that, as recorded in Watts' "Dictionary of the Economic Products of India," Dr. Thompson, at that time Government agent in Madagascar during the years 1813 to 16, sent 13 kinds of cane from that island to the Botanical Gardens in Mauritius. He also states that when the French were driven out of Madagascar in 1657 they took the cane of Madagascar with them to the island of Bourbon. From Bourbon they moved to Mauritius in 1715 and Dr. Thompson thinks that this Madagascar cane was the original basis of the sugar industry in both of these islands. One of the varieties which he sent to Mauritius he identified as identical with the cane originally cultivated there. This bit of overlooked history simply shows how difficult or usually impossible it is to really trace the origin of even the best known of the older kinds. The fact that they were brought from a given country by no means proves that they really originated there. The Malays have been bold navigators for centuries and the fact that they are accustomed to carry sugar cane on their voyages as part of the provision for the crew makes it certain that the more popular kinds were given a wide distribution centuries before the records of cane literature began. There is little doubt but what such well-known kinds as Otaheite, Crystalina, Morada, Rayada, Yellow Caledonia and Cavengerie occur again and again in the following list disguised

under local names. In fact, there is nothing uncommon for the same kind to be known under widely different names in different parts of even one small island. The following list of the names that have been applied to cane varieties in different parts of the world instead therefore of being a contribution to our real knowledge of cane varieties will mainly be useful in calling attention to our lack of knowledge regarding most of them. It is not expected that this list will prove complete. A further search of the literature will unquestionably bring to light many additional names. This will, however, serve as a beginning to which additions may be made, and it is hoped that it may stimulate some interest in determining synonymy. In each case so far as possible the country of origin of the name is given and where synonyms are given the authority for the statement is indicated. The place of publication is also indicated so that it may be located in the bibliography which follows the list. The initials used in connection with numbers to designate the new seedlings varieties are also included in the list so far as they have been determined, but no attempt has been made to list the almost countless new seedlings.

AN ANNOTATED LIST OF THE SUGAR-CANE VARIETIES OF THE WORLD.

A:—(As an initial with numbers) = Antigua Seedling.
Aboe:—Mauritius Bot. Gar., 1869, Horn; Queensland, from Java, 1874, Easterby; Java, from Amboina, 1896, Wakker; White Aboe, Mauritius, 1869. = White Rappoe. Rappoe is a name that has been rather loosely applied but is usually considered. = Light Cheribon (Crystalina).
Agholi:—India, N. W. Prov., Watts' Dict. 6(2): 62, 1893.
Agoeng:—Java, Harreveld, Med. 4: 1658, 1919.
Ainakea:—Hawaii, Eckert, Bull. 17, 1906; Deerr, Cane Sugar, 1911; Louisiana, from Hawaii, Stubbs, Agee. A green and red striped cane but not the striped Bourbon as suggested by Stubbs. (Deerr).
Akewa:—Queensland, 1878, Easterby; from New Guinea, Maxwell, 1903–4.
Akilolo:—Louisiana, from Hawaii, Stubbs, Agee. = Manulitb, Stubbs; Hawaii, Rock, 1913.
Albion:—Demorara, Jour. Brit. Gui. 11: 157, 1918; Albion Green, Jamaica, Sug. Sta. Rept. 2: 69, 1908 (= D 95); Albion Red, Sug. Sta. Rept. 2: 70, 1908 (= D 135). No explanation of the origin of this name is found. Probably should be disregarded.
Aleijada:—Brazil, Deerr, Cane Sugar 36.
Alfoeroe:—Java, from Ambonia, Wakker; Teboe Alfoeroe Soltwedel, Fig. 19. The plate indicates a green striped cane, with barrel-shaped internodes and broadly ovate buds.
Altamatti:—Hawaii. Eckert, Deerr; Louisiana, from Hawaii, Agee. = Cavengerie, Deerr, which see [probably a corruption of Otamite.]
Amarilla das Antillas:—Argentine, from Brazil, Zerban, 1910. See Cayanna [= Otaheite.]
Amarilla de Java:—Brazil, The Sugar Cane, 22: 483, 1890–; The Sugar Cane 25: 187, 1893.
Amarilla de Otaití:—Brazil, Moreira, 1876. See Otaheite.
Amarilla del Japón:—Brazil, The Sugar Cane, 22: 483, 1890.
Ambar de Egypto:—Argentine, Fawcett, 1916. = Java 105 P. O. J.
Ancha:—South Africa, from Formosa, Choles, 1913.
Andjing:—Java, from Sumatra, Wakker, 1896; Teboe Andong, Queensland, from Java, 1878, Easterby.
Ani:—Mauritius, from New Caledonia, Lavignac, The Sugar Cane 2: 674, 1870.
Annamite:—Queensland, from Singapore, 1880, Easterby.
Anson:—Mauritius, from Penang, Horne, 1869.
Anyagyan:—Burna, Watts' Dict. 6(2): 78, 1893.
Applewhaites Seedling:—Barbados, Rept. 1905–7: 23, 1908.

Arabora:—Queensland, from New Guinea, 1895, Easterby.

Ardjoeno:—Mauritius, from Java, Horne, 1869; Queensland from Java, 1874, Easterby; Java, 1896, Wakker, Geerligs, Soltwedel, Fig. 5. The plate represents a medium stout, long-jointed, green cane somewhat yellow by exposure, marked with lines on upper part of internode, slightly staggared; buds ovate.

Aripibu:—Brazil, Gorkum 29, 1915; Aripibu Verde, Pernambuco, Bull. 3. An indigenous yellow-striped cane.

Ariva:—New Caledonia, Vieillard, 1869, Sagot 347, 1893.

Armstrong:—Demorara, Harrison & Jenman. Purple, then dark claret, covered with bloom. This name does not appear elsewhere.

Arolam:—New Caledonia, Vieillard, 1863, Sagot 347, 1893.

Arundo Sacharifera:—Rumphius Herb., Amboinensis 5:186, 1747. A pre-Linnaean scientific name for sugar cane. =*Saccharum officinarum L.*

Asamiga puri:—Assam, Stack, 1883, Watts' Dict. 6(2): 62, 1893.

Ashy Mauritius:—India, Barber, Studies 2; Mysore Agri. Calendar, 1915.

Assep (or Woelong):—Java, Krazenbrink, The Sugar Cane 2:192, 1870; Mauritius, from Java, Horne 1869; Queensland, from Java, 1878, Easterby. Woelong is considered by Gonsalves as a synonym of Black Cheribon.

Assoe:—Java, from Sumatra, Wakker, 1896.

Atjeh:—Java, from Sumatra, Wakker, 1896.

Australian Creole:—Australia, Erwin F. Smith, Bacteria & C. 3:69, 1914. Said by Tryon to resemble Meera and to resist Gum Disease. Meera is usually considered as a synonym of Black Cheribon, but the Cheribon canes are all more or less subject to Gum Disease.

Avae:—Society Islands, Cruzent, 1860; Tahiti, Bennett, The Sugar Cane 6:593, 1874.

Aveha:—South Africa, from Formosa, Choles.

Aver:—Java, from Sumatra, Wakker, 1896.

Awie (also spelled Awi):—Java, from Sumatra, Wakker 1896; Kobus, Med. 6, 1893.

Awoe de Pasoeroean:—Java, Krajenbrink, The Sugar Cane 2:192, 1870.

Awoe de Teloek Djambie:—Java, Krajenbrink, The Sugar Cane 2:192, 1870.

Ayoena:—Mauritius, The Sugar Cane 2:223, 1870. Presumably from Java since it is called Teboe Ayoena.

B.:—(As initial with numbers) = Barbados Seedling. The long list of seedlings produced by Bovel in Barbados some of which are extensively cultivated in all parts of the world. A second series of B numbers seems to have been started (see Rept. 1915–17: 62, 1917). B following a number indicates a seedling produced in Java by Bruïcius.

Ba:—(As initial with number) = Another series of Barbados Seedlings. See Rept. 1907-9: 46, 1910. No explanation of this Ba series has been found. These numbers run into several thousand.

Badilla:—(Also spelled Badila) Queensland, from New Guinea as No. 15, 1896, Maxwell, Easterby; Barbados Rept. 1911, Trinidad, Williams, Bull. 18: 72, 1919. (desc).

Badouka:—Cent. India, Watts' Dict. 6(2): 69, 1893.

Bagelen:—Java, Kobus, Med. 6, 1893.

Bagi:—Assam, Stack, 1883, Watts' Dict. 6(2): 62, 1893.

Bahmani:—Bombay, Watts' Dict. 6(2): 73, 1893.

Bahr:—India, Watts' Dict. 6(2): 70, 1893; also Bharar, p. 71.

Baidaa:—Java, from Sumatra, Wakker, 1896.

Bajam:—Java, from Sumatra, Wakker, 1896.

Bakhra:—United Prov. India, Barber, Studies 3; Bakri, Watts' Dict. 6(2): 62, 1893.

Bali Soerat:—Java, Oost-Java Med. 9: 19.

Bambóo:—(Also written Bamboe, Bambou and Bambú) A name widely but somewhat loosely applied in sugar-cane literature. It is usually supposed to apply to an erect green cane with enlarged nodes. Deerr identifies it with the Kulloa of India. Bamboo I & III = Meligeli, Harrison and Jenman. Bamboo II = Bourbon, Harrison & Jenman. Rose Bamboo, Hawaii = Crystalina, Deerr.

Bambou Blanc:—Mauritius, Boname, 1895.

Bambou de Cera:—Brazil, The Sugar Cane 22: 483, 1890.

Bambou Jaune:—Reunion, Colson, 1905.

Bamboe Poetih:—Java, from Fiji, Wakker, 1896.

Bambou Rayée:—Mauritius, Boname, 1895; New South Wales, Int. Sugar Journ. 1: 506, 1899.

Bambú Rosada:—Porto Rico, Stahl, 1880; Bambou Rosée, Reunion, Colson, 1905.

Bambú Rosada de Rayas Moradas:—Porto Rico, Stahl, 1880.

Bambou Rouge:—Queensland, from Mauritius, 1902, Easterby.

Bambú de Tabandí:—Argentine, from Brazil, Zerban, 1910. In later publications = Kavengire [Uba].

Banjermassing:—Java, Kobus, Med. 6, 1893.

Banjermassing Hitam (or Item):—Java, Wilbrink & Ledebour, Med. 6: 86, 1911 = Borneo, Harriveld, Med. 15: 1597, 1917.

Banjermassing Poetlih:—Java, Kobus, Med. 6, 1893.

Bangadya:—Bombay, Watts' Dict. 6(2): 73, 1893; Knight Bull. 61, 1914. As Bangdia, Watts' Dict. 6(2): 75, when according to Ozanne's classification it includes, Kabara, Bharal, Bhonga, Rambali, Ramurasdali, Rudraganthi and Dhamne.

Bangla:—India, Watts' Dict. 6(2): 67, 1893.

Bangsa:—India, Watts' Dict. 6(2): 57, 1893; Java, from Bovenlanden, Wakker, 1896.

Banka:—Java, Med. 25:1; Banka Groen, Banka Rottan, Banka Soerat and Banka Wit, Kobus, Med. 6, 1893.

Bansa:—India, Watts' Dict. 6(2):60, 1893; Taylor, Sabour, 1913; Woodhouse, Mem. 7(2), 1915.

Bansbarra:—India, Watts' Dict. 6(2):70, 1893.

Bansi:—Bombay, Barber, Studies 3.

Banteng:—(Also written Banting) Java, Wakker, 1896.

Bantong:—Mauritius, Horne, 1869. (Written Teboe Bantong so presumably from Java.)

Bantool:—Java, Harriveld, Med. 15:1597, 1917.

Baraukha:—India, United Prov. Barber, Studies 3: Sabour, Taylor 1913; Woodhouse, Mem. 7(2). 1915. [See Barookh and Baroukha.]

Barbados:—Demorara, Harrison & Jenman = Po-a-ole. [= Cavengirie.]

Barbados Native:—Demorara, Harrison & Jenman = Creole.

Barha:—North India, Barnes.

Barhai:—North India, Barnes.

Barik Pandparu:—Bombay, Knight, Bull. 61, 1914. A soft white cane.

Barkley:—Jamaica, Bull. 2, Bull. 4, 1897, introduced from Mauritius 1882, Sir D. Morris. This name does not appear in the Mauritius lists. It seems to be confined to Jamaica.

Barli:—India, Watts' Dict. 6(2):71, 1893.

Barookh:—Java, from English India, Kobus, Med. 48, 1893; Van Derventer, Handb. 5:141, brought by Kobus in 1890. See Baraukha.

Barotamic:—Mauritius, from New Caledonia, Cavignac, Horne, 1869.

Baroukha:—India, Barber, Studies 2. See Baraukha.

Baruka (also Barukka):—India, Watts' Dict. 6(2):60, 1893; Papers-Sugar-Brit. India 3d. ap: 35, 1822. See Baraukha.

Bas:—Bombay, India, Knight, 1914. A soft ash-colored cane.

Basin:—Bengal, India, Watts' Dict. 6(2):60.

Bastard Cane:—Georgia, U. S. A., Yoder, Bull. 486 Local name given to a green bud sport from Ribbon. = Crystalina.

Batavian:—A name occurring widely in the literature; usually used in the same sense as Cheribon and including the Purple, the Striped and Crystalina. Mentioned by MacFadyen in Jamaica, by Porter, and by Wray. Transparent is often used in the same sense.

Bati:—Mauritius, from New Caledonia (Lavignac), Horne, 1869.

Batjan:—Java, Van Derventer, Kobus. Seems to be used in same sense as Batavian. Batjan Groen, Soerat and Keong are mentioned.

Batoe:—Queensland, from New Guinea, 1895, Easterby. Maxwell: Java Kobus.

Batoeng:—Java, from Sumatra, Wakker, 1896; Soltwedel, Fig. 4. Plate shows a stout, greenish cane with a slight reddish flush, much darkened by sooty mould; nodes oblique, slightly constricted; somewhat staggared; buds rather large, suborbicular.

Batramic:—Demorara, Harrison & Jenman.
Batramie:—Jamaica, Bull. 2., introduced from Mauritius in 1882, D. Morris. Another new name for some old cane.
Batse Purple:—N. S. Wales, Int. Sug. Journ. 1: 506, 1899.
Behar:—North India, Barnes.
Beija Flor:—Pernambuco, Brazil, Bull. 3. Striped.
Belang:—Java, from Sumatra, Wakker 1896.
Beledi:—Louisiana, from British India, Agee.
Belnoet:—Java, from Sumatra, Wakker, 1896.
Belonguet:—Mauritius, 1850. Also written Bellouguet, Beloguet, Belugué, etc. The name originated in Mauritius from a plantation of that name. It is simply the Black Cheribon. = Taboe Batavia (Wray), = To Ute, Society Islands (Diard). Other red canes have been confused under this name. Some of the Australian references clearly do not belong here. Belugué Blanco, Rayado and Rojo, Porto Rico, Stahl, are all used as synonyms for Salangore Blanco, Rayada and Rojo. The two latter probably refer to the Cheribon Canes. [See Canne Belouguet.]
Benaresia Nepali:—India, Sabour, Taylor; Woodhouse, Mem. 7(2), 1915. A thick cane closely related to and possibly identical with Shamshara.
Bengal, or Bombay:—Assam, Stack 1883, Watts' Dict. 6(2). Bengala, from Calcuta, Porto Rico, López Tuero, 1895.
Bengkoeloe:—Java, from Sumatra, Wakker, 1896.
Beraran:—Java, from Borneo, Geerligs, Med. West Java 27.
Besi:—Java, Med. Oost, Java, 11: 30.
Betakali of Dumraon:—North India, Barnes
Bete Bete:—Mauritius, Bouton, 1863. See Canne Malabar. [Perhaps = Striped Cheribon.]
Betong:—Java, from Bovenlanden, Wakker, 1896.
Betta:—Bombay, Knight. See Khadya.
B. F.:—As initials with numbers. = Beija Flor, Pernambuco, Brazil, *Bull.* 3., *da Estacao Exp. de Canna de Assucar.*
B. H.:—As initial with numbers. = Barbados hybred, used for hybred seedlings of known parantage by Bovel in Barbados. B. H. 10(12) is now extensively planted there.
Bhabeli, or Kamrange:—Assam, Stack, 1883, Watts' Dict. 6(2): 62.
Bhanisiawarchota:—India, Watts' Dict. 6(2): 71.
Bharal:—India, Watts' Dict. 6(2): 72.
Bhoronga:—India, Watts' Dict. 6(2): 60.
Bhunli:—Bengal, India, Chapman, Watts' Dict. 6(2): 60.
Bhuri:—Sabour, India, Taylor; Woodhouse, Mem. 7(2). See Bombay.
Bhurli:—India, Shahabad, Watts' Dict. 6(2): 60. Java, from English India, Kobus.
Bhurree:—Cent. India, Watts' Dict. 6(2): 69. See Bhuri.
Big Bellaint:—Queensland, from Mauritius, 1878, Easterby. [Probably a corruption of Belouguet.]

Big Elephant:—Queensland, McDonald, The Sugar Cane 14:423, 1882. (See Elephant.)

Big Ribbon:—Queensland, from Caledonia (Caldwell), = Caledonia Ribbon, J. Davidson, 1880. Introduced from Honolulu 1895, Easterby. = Striped Tanna, Deerr.

Big Tanna:—Mauritius, 1892, Walters; Reunion, Colson, 1893. Barbados, Rept. 1917–19:60. (See Tanna.)

Big Tanna Rayée:—Queensland from Mauritius 1901, Easterby. [= Striped Tanna.]

Big Yellow:—Queensland, 1880, J. Davidson, disc. [Seems to = Yellow Caledonia.] McDonald, 1882, writes Big Yellow or Caledonian Ribbon. Easterby reports Big Yellow as a sport of Big Ribbon.

Bile:—Bombay, India, Watts' Dict. 6(2):73; Bily, Madras Watts' Dict. 6(2):76.

Billiton:—Java, Kuijper, Med. 7:814, 1917.

Bily-Cabo:—India, Papers—Sugar, &c., 3d. Ap. 17, 1882. [See Bile.]

Bira:—Java, from Sumatra, Wakker, 1896.

Bird:—Louisiana, Stubbs. A light-purple bud sport [from striped Cheribon. Queensland, from Louisiana, 1905, Easterby.

Bittong Beraboo: = Salangor, Wray, Deerr.

Black Borneo:—Schwarze Borneorohr. = Tebu Item, Borneo. Kuger: 141.

Black Cane:—Jamaica, MacFadyen; N. S. Wales [= Black Cheribon], Java, Gonzalves, = Teboe Woeloeng, Teboe Item, Teboe Moujet, and Canne Violette of Humbolt & Bonpland in part. [= Black Cheribon]. Brazil, = Black Tanna? Deerr. Pernambuco, Brazil, = Port Mackay, Int. Sug. Jour. 1:378, 1899 [Cavengirie].

Black Cane of Jamaica:—Argentina = Morada [= Black Cheribon].

Black Cane of New Caledonia:—Mauritius, 1869 Horne. [= Black Tanna?]

Black Cheribon:—Schwarze oder Cheribonrohr, = Gonsalves, Zwart riet, Tebu itam, (Tmoujit?), Tebu Tjeribon, Canne Violette, Kruger. = Belouguet, Black Java, Dark Bamboo, Diard, Gonzalves, Meera, Moores Purple, Purple Bamboo, Purple Mauritius, Purple Violet, Queensland Creole, Tabor numa, Tebboo Etam, Deerr. [= Louisiana Purple.]

Black Creole:—Jamaica, West Ind. Bull. 6:329, 1906 [= Black Cheribon].

Black Fiji:—Queensland, from Mauritius. 1878, Easterby.

Black Issacs:—N. S. Wales, Int. Sugar Jour. 1:506, 1899.

Black Java:—Usually considered to = Black Cheribon but in Mauritius Boname (Rept. 1896) notes two different canes under this name, one resembling Otamite and the other Port Mackay [= Cavengerie]. In Queensland Davidson, 1880, makes it = Chicaca from Queensland Bot. Gar., Mapou from Mauritius, Mma Cane from New Caledonia (Caldwell) and Tibbou Etam from Batavia (Wray). He describes it as having "cane itch strong," which

of course throws his cane out of Black Cheribon, which has glabrous leaf sheaths.
Black Manila :—See Inalmon.
Black Nepaul :—Mentioned by Wray.
Black Ribbon :—Jamaica, see Mam Blam.
Black Tanna :—Queensland, from Mauritius 1878, Easterby. A local sport from striped Tanna, Mauritius Dept. Agr. Bull. 2:.5, 1916. Has no synonyms, Deerr and Eckert Hawaii Bull. 26:16, 1908.
Blackman's Seedling :—Barbados See Sealeys Seedling.
Blambidjie :—Java from Malacca, Wakker, 1896.
Blanca de Otaheite :—Louisiana, Stubbs, [= Otaheite = Caña Blanca].
Blonga :—Bombay, India, Watts' Dict. 6(2) : 74.
Blorek :—East Java, Med. 11: 29.
Blue : = Crystalina, Deerr.
Blue Ribbon :—Tortola, Virgin Isl. B. W. I. Rept. Imp. Dept. 1817–18: 3. This seems to be a local variety.
B. N. H. :—Barbados, as initials with numbers means natural hybreds from "checker board" plantings.
Boadilla :—Mauritius, from Australia, Bull. 22: 32, 1910. [a missprint for Badilla].
Bodi :—North India, Barnes.
Boeloeh Balik :—Java, from Borneo, Wakker, 1896.
Boeloeh Gading :—Java, from Borneo, Wakker, 1896.
Boeloer :—Java, from Sumatra, Wakker, 1896.
Boeloer Koering :—Java, from Sumatra, Wakker, 1896.
Boiepe :—New Caledonia, Vieillard, 1863, Sagot. 348.
Boinliona :—New Caledonia, Vieillard, 1863, Sagot: 346.
Bois Rouge :—Mauritius, from New Caledonia about 1870, Dept. Agr. Bull. 2: 11, 1916; Demorara, = Bouronappa, Harrison and Jenman; Queensland, Maxwell, Easterby; Porto Rico, = Palo Rojo, Stahl, 1880; Brazil, = Vermehla, Deerr; Argentina, from Brazil, Zerban.
Bois Rouge Blond :—Porto Rico, Stahl, 1880; Reunion, Sagot: 330, 1893.
Bombay :—Bengal and Assam; not known under this name in Bombay; a red cane probably from Mauritius, Watts' Dict. 6(2) : 76. Sabour, India, Taylor. = Red Bombay, = Bhuri, Woodhouse.
Bonsi :—Cent. India, Watts' Dict. 6(2) : 69.
Bontha :—Louisiana, from British India, Agee.
Borbon :—[See Bourbon] Porto Rico, Stahl, López Tuero. Both consider it as distinct from Otaheite.
Borneo :—Mauritius, Boname, 1895; Java, Van Derwinter, 1915. = Bandjarmassin Item. Queensland from Mauritius 1902, Easterby. Argentine, from Brazil. = Tebu Merah Borneo, (Kruger) ? Zerban.
Borneo Idjo :—Java, Med. 6, 1893, Kobus.
Borneo Itam :—Java, Med. 6, 1893, Kobus.
Borneo Rouge :—Queensland, from Mauritius, 1901, Easterby.

Borneo Soerat:—Java, Med. 6, 1893, Kobus.

Borou:—Queensland, from So. Sea Islands, 1874, Easterby.

Bote:—Queensland, from So. Sea Islands, 1874, Easterby.

Bouranappa:—Jamaica. See Bouronappa.

Bourbon:—As usually used = Otaheite (which see for synonyms). Louisiana, Fleischman, 1848, = Black Cheribon [Louisiana Purple]; the colored plate is unmistakable. Louisiana, Stubbs = White Cheribon [Crystalina]. Trinidad, Hart suggests there are several yellow varieties included under this name. Australia, from Queensland, not Bourbon of W. Indies; right name is Bamboo, Melmouth Hall, 1873. Queensland, 1880, Davidson says = Taboe Leeut of Singapore, Taboe Otaheite of Java, Green & Yellow of Mauritius, but adds "Cane itch none"; evidently some other cane. Egypt, Tiemann writes: "This red cane apparently springs from the Bourbon or else is identical with it"? Java, a red cane, not the Bourbon of W. Indies, Deerr. Argentine, introduced from Brazil, seems distinct from Bourbon of W. Indies, Zerban.

Bourbon Purple:—So. Africa, from Bourbon? Choles.

Bouron:—Mauritius, from New Caledonia (Levignac) 1870, Horne.

Bouronappa:—Jamaica, from Mauritius 1882, D. Morris. Demorara, = Bois Rouge, Harrison and Jenman.

Bouron Vapoa:—Mauritius, from New Caledonia (Lavignac) 1870, Horne.

Bourow:—Jamaica, introduced from Mauritius 1882, D. Morris = Bois Rouge?, Bowery Bull. 4: 227, 1897. [See Bouron.]

Branche Blanche:—Java, from Mauritius, Wakker, 1896; Soltwedel, Fig. 25, represents a medium stout claret-red cane with bronze stripe; the text says leaves often show white striping. Three canes represented, the center one darker colored and without stripes, buds rather large, ovate triangular. Clearly Cavengirie, though buds are not typical. Soltwedel evidently did not appreciate bud characters and was careless in drawing them.

Branchu Blanche:—Mauritius, a self-colored sport of Branchu Rayee, = Cavengirie, Deerr.

Branchu Rayee:—Mauritius, = Tibboo Soerat Mauritius, Deerr. This seems to be an error since Teboe Soerat Mauritius Soltwedel, Fig. 24, is an entirely distinct cane, quite different from Cavengirie.

Bra-oto:—New Caledonia, (Breslau) 1884, Sagot: 333.

Brate Mie:—New Caledonia, (Breslau) 1884, Sagot: 339.

Brate Pa:—New Caledonia, (Breslau) 1884, Sagot: 339.

Brazilian:—Used by Porter, 1843, for the cane grown in the West Indies before the introduction of the Otaheite, = Creole.

Brea:—Mauritius, Boname, Rept. 1898–9.

Breheret:—Jamaica, from Mauritius, 1882, D. Morris; Demorara, (Spelled Brekeret) Harrison and Jenman; Java, from Malacca, Wakker, 1896; Louisiana, from Jamaica, Stubbs, Agee. The name seems to have originated in Jamaica.

Brighton Seedlings:—Brighton estate, St. Kitts, 60 seedlings produced and tested, Imp. Dept. Agr. Rept. Leeward Isl. 1916–18:75, 1919.

Brisbane:—Jamaica, from Mauritius 1882, D. Morris; Louisiana, from Jamaica, Agee. = Green Rose Ribbon, Stubbs, Deerr.

Bronzeada:—Brazil, = Roxinha, Deerr.

B-(ruicius):—As initial following Java Seedling numbers indicates seedlings produced by Bruicius. Many of them are crosses with the Red Fiji, which resists Sereh.

Brown Pink:—Queensland, from Bot. Gar. (Spiller), Davidson, 1880. "Itch plentiful."

B. S. F.:—Barbados, as initials with seedling numbers means "bagged and self-fertilized." Rept. 1908–10:31, 1911.

Bundaberg:—Queensland, = D 1135. Easterby.

Bundya:—or Pahdhra, Bombay, Watts' Dict. 6(2):73.

Burk:—Barbados; a chance seedling, named for the overseer who discovered it. Bovell, West Ind. Bull. 2:25, 1901. Demorara, Harrison and Jenman. = Crystalina, Deerr.

Burra Chunnee:—India, United Prov. Barber Studies 3. = [See Chunnee.]

Buxaria:—India, Taylor, Woodhouse

Caanan:—Jamaica, Sug. Exp. Rept. 1905.54, 1896

Cadjoolee:—India, Papers—Sugar, &c, 1822; a thick purple cane mentioned under date of 1792, with a poor-colored plate. Said to be the best cane grown there and that people from West Indies do not know it.

Calancana:—Porto Rico, = Imperial del Brazil, Stahl, 1880. [= Green Ribbon.]

Caledonia:—Louisiana, from Demorara, Agee. 1911.

Caledonian Queen:—Trinidad; provisional name proposed by Mr. Purdie, 1879. No mention of origin. The first importations into Trinidad seem to have been by number and names were applied later according to fancy. Jamaica Bull. 4:227, 1897, = Java, = Hope, = White Elephant. Barbados Rept. 1905–7, Louisiana, from Demorara, Agee. Demorara = White Transparent Harrison and Jenman.

Caledonian Rayée:—Guadaloupe, recently introduced from New Caledonia, Boname, 1888. Mauritius and Reunion, from New Caledonia. Sagot: 328, 1893. [= Striped Tanna.]

Calvacante:—Brazil, = Manteiga, Deerr.

Camfia:—Amboina, Rumphius, a native name for sugar cane.

Canaan Cane:—Jamaica, Rept. 3:84, 1911. [See Caanan.]

Caña Blanca:—Porto Rico, Stahl, López Tuero. The common Spanish-American name for Otaheite.

Caña de India:—Argentine. See Otaheite.

Caña Morada:—Negros, Philippines, Walker. The common Spanish-American name for Black Cheribon.

Caña Negra:—Porto Rico, a popular name for the dark, self-colored variant of Cavengerie. Negros, Philippines, Wakker. Seems to be used for the purple-leaved red cane, = Djamprik.

Caña Roja de Borbón:—Porto Rico, López Tuero. See Crystalina.
Caña Veteada:—Mexico, Fernández del Castro. [= Rayada.]
Caña Violeta de Batavia:—Mexico, Fernández del Castro; also called Habanera. Leave are purplish. [= Djamprik.]
Canna da Terra:—Brazil, = Crioula [Creole], Moreira, 1876.
Canna de S. Juliao:—Brazil, Moreira, 1876.
Canna do Governo:—Sao Paulo, Brazil, Sawyer, 1908.
Canna Escoscia S. Simao:—Sao Paulo, Brazil, Sawyer, 1908.
Canna Maca:—Sao Paulo, Brazil, Sawyer, 1908.
Canna Mestica:—Sao Paulo, Brazil, Sawyer, 1908.
Canna Molle:—Brazil, Moreira, 1876.
Canna Rosa:—Sao Paulo, Brazil, Sawyer, 1908.
Canne Bambou:—Mauritius, Bouton, 1863. From the long description this seems to = Crystalina. It is probably the source from which came the name Rose Bamboo used for this variety in Hawaii.
Canne Beloujuet:—Mauritius, Bouton, 1863. Three numbers are described under this name. No. 1 = Canne Rouge (of Bourbon), the Purple Violet or Large Black Java (of Wray), *Saccharium violaceum* Tussac. This probably = Black Cheribon. No. 2 is named *Sac. Violaceum var. purpureum,* and No. 3 is *Sac. Violac. var spadeceum.* [See Belouguet.]
Canne Blanche:—Mauritius, Bouton, 1863, = Canne Jaune (Maurice) Canne de Batavia (Reunion), Taboe Otaheite (Java), *Sac. officinarum* var. *elongatum.* [Evidently = Otaheite.]
Canne Blanche de Tahite:—Sagot: 324, 1893, = To Uouo, is To Vaihi. Canne de Sandwich. Greatly resembles the last [Canne Jaune de Tahiti], but is less juicy, this cane is richest in Crystalizable sugar of all known varieties. [Sagot evidently thinks more than one cane is included under the name Otaheite.]
Canne Blanche de Otaiti:—Guadeloupe, Boname, 1888, = Canne de Batavia (Reunion), Canne Jaune (Maurice), Canne Bourbon or d'Otaiti, (India, Antilles &c.) [as here used = Otaheite].
Canne Bonne Blanche:—Jamaica, Tussac 1808, green shaded with violet, the agent at Hope plantation is propagating it as rich in sugar. [Doubtless = Crystalina.]
Canne Crieole:—Mauritius, Bouton, 1863, ≠ Canne du Pays (Maurice) Canne Blanche du Pays (Bourbon). *Sac. Violaceum* var. Album. [= Creole.]
Canne. de Batavia:—Mauritius, Bouton, 1863, = Otaheite; Guadeloupe, Boname, 1888 = Canne Violetta. [= Black Cheribon.]
Canne de Graine:—Mauritius, Boname, 1895. [See Graine Blanche and Graine Rouge.]
Canne de Rurutu:—Sagot: 329, 1893, = To Rurutu (Rurutu), To Rutu (Tahiti).
Canne de Salangore:—See Salangor.
Canne d'Egypte:—Reunion, Colson, 1905.
Canne d'Otaite rubanée:—Guadeloupe, Boname, 1888; the kind most planted in Maurnius and Reunion, probably Canne Guingham or Canne d'Otaité Rayée. [= Striped Cheribon?.]

Canne Diard Rayée:—Guadeloupe, Boname, 1888, [= Striped Cheribon].

Canne Diard Rose:—Mauritius, Bouton, 1863, [= Crystalina?].

Canne Diard Verte:—Mauritius, Bouton, 1863, [= Crystalina?].

Canne Grosse Verte de Tahití:—Sagot: 324, 1893, = To Irimotu. "Has much cane itch; rich in sugar."

Canne Guingham:—Mauritius, Bouton, 1863, = Canne Maillard, Canne Violette (Maurice et Bourbon), Red Ribbon of Batavia (Wray), Taboe Soerat (Java), *Sac. officinarum* var. *vittatum*. According to Deerr this = Striped Tanna, but there is much confusion in the literature between Striped Tanna and Striped Cheribon.

Canne Imperial:—Mauritius, from Brazil, 1869. Horne. [= Green Ribbon.]

Canne Jaune:—Mauritius, Bouton, 1863, = Otaheite.

Canne Jaune de Tahiti:—Sagot: 334, 1893, = To Avae, Tebbou Otahiti (Java). He designates the following as sub varieties: Tebbou Njamplong (Java), Caña Solera (New Granada), Canne de Cayenne (Brazil), Canne de Bourbon or d'Otaití (des Antilles), Canne Jaune (Mauritius) [= Otaheite.]

Canne Jaune de Taiti:—Jamaica, Tussac, 1808, with colored plate 25, fig. 2. [= Otaheite.]

Canne Malabar:—Mauritius, Bouton, 1863, = Bete Bete. Malabar is usually given as a synonym for Yellow Caledonia. Here it is used for a striped cane, probably striped Cheribon.

Canne Martinique:—Mauritius, from Reunion, 1869, Horne.

Canne Mazerieux:—Mauritius, from Reunion, 1869. Horne.

Canne Morte:—Java, Kobus, 1893; from Malacca, Wakker, 1896; = Fiji, Deerr. Immune to Sereh and much used by Bruicius as the staminate parent in his crosses.

Canne Mozambique:—Mauritius, Bouton, 1863, = Canne Novie (Bourbon), *Sac violaceum* var. *nigrum*. Has wine-colored leaves; believed to have come from Madagascar but Diard saw it also in Java. [= Djamprik.]

Canne Panoche:—Louisiana, Diamond, 1886, introduced by La Pice from Java. Much like Crystalina but earlier. [= La Pice = Crystalina.]

Canne Pinang:—Mauritius, Bouton, 1863. See Salangore.

Canne Noire:—Guadeloupe, Boname, 1888.

Canne Reine Rouge:—Reunion, Sagot: 330, 1893.

Canne Ribbon:—Mauritius, from Brazil, 1869, Horne.

Canne Rocha:—See Salangore, Deerr.

Canne Rouge:—Mauritius, Bouton, 1863. See Canne Beloujuet. [= Black Cheribon.]

Canne Rouge de Java:—Sagot: 329, = Canne Belonjuet Rouge (Mauritius), Tebbou Rood (Batavia), Tebbou Japparah, Tebbou Merah (Malacca). [= Black Cheribon.]

Canne Rubinée:—Jamaica, Tussac, 1808, Plate 25, fig. 4. = *Sac. fasciolatum*, called Guingham in Batavia. Sheaths glabrous. [Clearly = Striped Cheribon.]

Canne Rubinée de Batavia:—Sagot: 327, = Canne Transparente à Rubens, Red Striped Cane, Fausse Canne Guingham, Canne Diard Rayée. [= Striped Cheribon.]

Canne Rubinée d'Otahiti:—Sagot: 327, = Cane d'Otahiti Rayée, Purple Striped Cane, Otaheite Ribbon, Tebbou Soerat, Canne Guingham, Canne Maillard. Sheaths glabrous. [= Striped Tanna but not clearly distinguished from the above.]

Canne St. Julien:—Mauritius, from Brazil, 1869, Horne.

Canne Uba:—Mauritius, from Brazil, 1869, Horne; "a worthless cane." [= Uba.]

Canne Verte:—Mauritius, from Brazil, 1869, Horne.

Canne Violette:—Mauritius, Bouton, 1863, = Canne Guingham [Striped Tanna]; Java, Gonsalves, = Black Cheribon.

Canne Violette de Batavia:—Sagot: 328, = Canne Purpure, Tebbou Moujet (Cheribon), Tebboe Assee or Woelong (Krawang), Tebbou Itam (Straights settlements), Purple Violet (India and Louisiana), Black Imperial (Jamaica), Canne d'Otaheite (Bourbon, Mauritius), To Ute (Tahiti, imported). [= Black Cheribon.]

Cannhina:—Argentine, from Brazil, Zerban, 1910. [= See Cayannhina.]

Canninha:—Sao Paulo, Brazil, Sawyer, 1908.

Canteng:—Queensland, from Java 1874, Easterby.

Cappor:—Tebboo Cappor, Wray, Queensland, from Java, 1878, Easterby. = Salangore Deerr.

Carandali:—Porto Rico, Stahl, 1880, López Tuero, = Imperial del Brazil. (See Calancana). [= Green Ribbon.]

Caricabo:—India, Papers—Sugar, 3d Ap. 114, 1822. A black cane. Madras, Watts' Dict. 6(2): 76.

Carp:—Java, used with numbers, Ledeboer, Med. 4·452 1917.

Castle:—Barbados, Nos. 1 and 2 are given. Rept. 198–10: 50, 1911.

Cavalcanti:—Brazil Gorkum, 1915. [See Calvacante.]

Cavengirie:—Porto Rico, Stahl 1880, from New Caledonia, also spelled Scavengirie and Covengerie, López Tuero. Hawaii, = Altamattié and Po-a-ole (Stubbs), Port MacKay (in Mauritius, not Java), Bullock Heart (Hawaii). Louzier (Brazil not Mauritius), Cheribon (Queensland, not Java), Cavengerie or Scavenger in Mauritius is distinct, Deerr and Eckert. Argentine, probably = Morada del Brazil, Louzier da Maurice, Kissman, Roxa Osema da Sao Simao, Zerban, Rev. 1: 29, 1910. Java = Branche Blanche of Soltwedel. Queensland = Cheribon; the unstriped form, = Cutamotee, from New Caledonia, Davidson, = Otamite, Easterby (but probably not of Mauritius). [Not Kavangire, Brazil, Argentine, Porto Rico.] See Kavarangri, New Caledonia, Breslau, 1884, probably the original source of the word.

Cawnpuri:—North India, Barnes.

Cayana Seedlings:—Porto Rico, from P. H. Yoder, Cairo, Georgia. Said to have originated at the Cayana Experiment Station, now discontinued.

Cayanna:—Brazil, Argentine. See Otaheite.
Cayanna de Sta. Barbara:—Argentine, from Brazil, Zerban.
Cayanna Rosa:—Argentine, from Brazil. See Rayada del País, Zerban.
Cayannhina:—Brazil, Deerr, Argentine, from Brazil, Zerban. [See Cannhina.]
Cayenne:— = Otaheite, Deerr.
Cebu Light Purple:—Philippines, Hines, 1915; a native cane.
Cebu Purple:—Argentine, from Philippines, Rev. 9(1):14, 1916.
Ceniza:—Porto Rico, Stahl, 1880, = Crystalina. [This name is often used for Crystalina in Eastern Cuba.]
Ceram:—Java, Kobus, Med. 6, 1893.
Cerane Geel:—Java, Kobus, Med. 6, 1893.
Cerane Rood:—Java, Kobus, Med. 6, 1893.
Cerane Soerat:—Java, Kobus, Med. 6, 1893.
Chaire:—India, Watts' Dict. 6(2):70.
Chalain:—Mauritius, Dept. Ag. Bull. 2:5, 1916.
Chalk Cane:— = Salangore, Deerr.
Chamar:—Mauritius, Duval, = Meera. Queensland, Davidson, Easterby, from Mauritius, = Meera.
Chan, or Chann:—India, Watts' Dict. 6(2):66, The Sugar Cane 15:594 and 644, 1883, (more than one variety seems to be included); Barber, Studies 1, = Katha.
Chapel Seedling:—Barbados, Rept. 1908–10:106, 1911.
Chareri:—India, Watts' Dict. 6(2):70.
Charkahiva:—India, Clark & Hadi, Ag. Inst. Pusa Bull. 13, 1908.
Chelus No. 1:—Queensland, from Mauritius, 1901, Easterby.
Chenoma:—Queensland, from New Guinea, 1895, Maxwell, Easterby.
Cheribon:—Name taken from a district in Java, used to include the three important commercial varieties, Black Cheribon or Morada, Light Cheribon or Crystalina, and Striped Cheribon or Rayada. All of which see for synonyms. When used alone it usually refers to Black Cheribon. Soltwedel, fig. 2, represents a plant of Black Cheribon attacked by Sereh. See Tjeribon. In Australia = Cavengirie in some of its forms, usually the self-colored, unstriped form.
Cheribon Koening:—Java, Wakker, 1896.
Cheribon Soerat:—Java, = Striped Cheribon.
Cherri:—India, Barber, Mem. 8(2), 1916; Mysore Agric. Calendar, 1915.
Chicaca:—Queensland, Easterby. See Chigaca.
Chicaga:—Queensland, and Demorara. See Chigaca.
Chief Branche:—Queensland, from Mauritius 1878, Easterby.
Chigaca:—New Caledonia, Lavignac, 1870, The Sugar Cane 2:674; Mauritius, from New Caledonia, 1869, Horne; Java, Wakker, 1896 (as Chijaca); Queensland, from So. Sea Islands, 1874. Easterby. Demorara, Harrison & Jenman. A red cane. [Seems much like self-colored Cavengirie.] [See Tichigaka.]
Chimna punda:—Bombay, India, Watts' Dict. 6(2):74.

Chin:—North India, Barnes, United Provinces, Barber, Studies 3. = Chunnee.

China:—Straits Settlements, Wray, described as a small, very hard, yellow cane, quite distinct from Otaheite. India Watts' Dict. 6(2):49, quotes Roxberg and Wray = *Sac. senensis* Roxb. Java, from Malacca, Wakker, 1896. Natal, The Sugar Cane 9:322, 1877. Demorara, Harrison and Jenman, China II = Bourbon, Jamaica; cane under this name seems to = Otaheite. Included as a synonym of Otaheite by Deerr.

Chine N(atal):—Mauritius, Boname Rept. 1896, & 1898–9, from Natal.

Chine P(amplemousse):—Mauritius, Boname Rept. 1896 & 1898–i. Considered distinct from the last by Boname; which one = China cannot be determined.

Chinese:—Queensland, Davidson, 1880. = China (Wray), Otaheite (Queensland Bot. Gar.), Creole (West Indies). Davidson's description agrees with that of Wray for China. The "very upright, narrow, pale-green leaves" agee with creole but "cane itch plentiful" shows it cannot be that kind, but a related variety. China or Chinese, therefore is recognized as = to Otaheite of Queensland not of West Indies, and as distinct from but similar to Creole, the former being hard with cane itch on leaf sheaths, the latter soft, with glabrous sheaths.

Chinkha:—India, Watts' Dict. 6(2):66.

Chinya:—India, Sabour, Taylor.

Chittan:—India, Barber Studies 2. A striped cane.

Chittuwasun:—Madras, India. Watts' Dict. 6(2):76

Chi-tu:—Nepal, India, Watts' Dict. 6(2):66, = Sano-gheura.

Chun:—India, N. W. Prov. Watts' Dict. 6(2):62 & 67.

Chunnee:—Java, from English-India, Kobus, Med. 48, 1893. Brought by Kobus in 1890, Van Derwinter Handb. 5:141. The male parent used by Kobus in his crosses mentioned under numbers followed by P. O. J. India, Barber, Studies 1, mentions as = Chin. United Provinces Studies 3.

Chyaca:—Jamaica, from Mauritius, 1882, D. Morris. [See Chigaca.]

Chynia:—India. Barber. Woodhouse.

Cima:—Queensland, from Java 1874, Easterby.

Cinzenta:—Brazil, Deerr, = Grossona.

Claret Cane:—Jamaica, MacFadyen, see Violet Cane, [= Black Cheribon], Java, from Malacca, Wakker, 1896.

Cleland Seedling:—Barbados, Rept. 1908–10:78, 1911.

Cochin China:—Java, Kobus, 1893.

Coki:—Queensland, from Singapore, 1880, Easterby.

Collyns:—Barbados, Rept. 1905–7:23, 1908; Rept. 1908–10:17, 1911; Louisiana, Agee, 1911.

Colony:—Demorara, Harrison and Jenman, = Bourbon. [= Otaheite.]

Common Green:—Erwin F. Smith. Bact. 3:69. Susceptible to Gum Disease. Georgia, = Otaheite, Yoder.

Common Red:—Trinidad, Williams, Bull. 18: 74, 1819, = Congo Red [= Cavengirie].

Congo Red:—Trinidad. See Common Red.

Corra Corra:—Queensland 1878, country of origin unknown, Easterby.

Country Cane:—Jamaica, MacFadyen, 1830, [= Creole]

Couve (with numbers):—Queensland, from Mauritius, 1901, Easterby. Louisiana, Agee

Crede:—Demorara, The Sugar Cane 29: 414, 1897 [a misprint; See Creole].

Creole:—Florida and Louisiana, Silliman, 1833, Fleishman 1848. Demorara, Harrison, Queensland, from West Indies, 1878, Easterby. = Brazilian, Porter. = Country Cane, MacFadyen, Jamaica. = Ribbon Cane, Argentina.

Criolla:—Porto Rico, Stahl, López Tuero. Argentina, Sihleh. [= Creole.]

Criolla Blanca:—Argentine, Fawcett, 1919, = Crystalina.

Criolla Morada:—Argentine, Fawcett, 1919, = Louisiana Purple, Morada Egypcia. [= Black Cheribon.]

Criolla Rayada:—Argentine, Fawcett, 1919, = Louisiana Striped, Egypcia Rayada, Ravanais. [= Striped Cheribon.]

Crioula:—Brazil, E. F. Smith. Argentine, from Brazil, Zerban. [= Creole.]

Crystalina (also written Cristalina):—The common Latin-American name for Light Cheribon, the most widely planted commercial cane. According to Stubbs = Bourbon from Trinidad, Green from Cuba, Hope (Jamaica), La Pice, Le Sassier, Light Java, Panachee, and Tibboo Merd. According to Deerr = Blue, Burk., Green, Hope, La Pice, La Sassier, Light Java, Mexican Bamboo, Mamuri, Mont Blanc, Naga B, Panachee, Rappoh, Rose Bamboo, Tibboo Merd. White Cheribon, White Transparent, Yellow Singapore and Yellow Violet.

Cuapa:—Jamaica, from Mauritius, 1882, D. Morris; Louisiana, from Jamaica, Stubbs, Agee.

Cuban:—Frequently met in the literature, usually = Otaheite.

Cullerah:—India, Papers—Sugar, &c., 1822. Mentioned in 1792 as growing in swampy land.

Culleroah: = Bamboo, Deerr.

Cutamotee:—Queensland, Davidson 1880. The description indicates = Cavengirie.

Cutarrah Red:—Mauritius, from India, 1869, Horne.

Cutarrah White:—Mauritius, from India, 1869, Horne.

Cuttaycabo:—India, Papers—Sugar, &c., 1822, Madras, Watts' Dict. 6(2): 76.

Cyana:—Brazil = Cayana. [= Otaheite.]

D. (as initial with numbers): = Demorara Seedling.

Dacca Gandari:—Bengal, India, Ag. Inst. Pusa., Bull. 83: 27, 1919.

Dadap Pasien:—Java, from Sumatra, Wakker, 1896.

Dama:—Demorara, Harrison & Jenman. Java, from Malacca, Wakker, 1896. The name seems to have originated in Demorara. [See Daura.]

Daniel Dupont:—Queensland, from Mauritius, 1878, Easterby. Java, from Australia, Wakker, 1896. E. F. Smith, Bact. 3: 69, Resists gum disease. = Striped Tanna, Deerr, but considered distinct by Easterby.

Dantur:—India, Watts' Dict. 6(2): 62.

Dark-Colored Bamboo:—Hawaii, Eckert, Bull. 10: 9, 1905. = Black Cheribon, Deerr.

Dark Purple (or Red Blouget):—Australia, from Isle of Bourbon, 1857, Melmonth Hall, The Sugar Cane 6: 588. [= Black Cheribon.]

Dark-Red Striped:—Java from Malacca, Wakker 1896.

Dark with Red Lines:—Brazil, the Sugar Cane 22: 183, 1890. [= Cavengirie].

D'Aryeli:—Haiti, Tussac 162, 1808.

Das Kabbu:—Bombay, India, Watts' Dict. 6(2): 73.

Daula:—India, Watts' Dict. 6(2): 66.

Daura:—Jamaica, from Mauritius 1812, D. Morris. (Is Dama a misprint for this name?)

Davonboota:—Java, from Malacca, Wakker, 1896.

Deci:—Java, from English India, Kobus, Med. 48, 1893.

Degehin:—Java, from English India, Kobus, Med. 48, 1893.

Degenerada de Quissman:— Brazil, Moreira, 1876.

Delenole:—New Caledonia, Vieillard, 1863, Sagot 346.

Delon:—New Caledonia, Vieillard, 1863, Sagot 347.

Demak Idjo Seedlings:—Java, the result of crosses on Black Cheribon made by P. J. Stock in 1903, Jeswit, Med. 5, 1918.

Demorara: = Meligeli, Harrison & Jenman, = Bamboo I & III. Deerr.

Desavali:—Madras, India, Int. Sugar Jour. 2: 471, 1900.

Desi:—India, Watt's Dict. 6(2): 67.

Desi Suretha:—North India, Barnes.

Desivari:—Madras, India, Int. Sug. Jour. 2: 469, 1900.

Devagadi:—Bombay, India, Knight. = Sannabile.

Dhali Surang Langli:—Assam, Stack, 1883, Watts' Dict. 6(2): 62.

Dhalsunder:—Bengal, India, Watts' Dict. 6(2): 60. Sabour, Taylor, Woodhouse.

Dhani:—India, N. W. Provinces, Watts' Dict. 6(2): 62.

Dhaori:—India, Watts' Dict. 6(2): 67.

Dhaulu:—India, Barber, Studies 1, 2, 3; North India, Barnes; Watts' Dict. 6(2): 67 also as Dowlo.

Dhaulu of Bham:—North India, Barnes.

Dhaulu of Phillaur:—India, Barber, Studies 1.

Dhaulu of Suretha:—North India, Barnes.

Dhaunr:—India, N. W. Prov. Watts' Dict. 6(2): 62.

Dhaura Kanar:—North India, Barnes.

Dhaura of Azamgarh:—India, Pusa, Clark & Hadi; North India, Barnes. A thick cane.

Dhola:—India, Watts' Dict. 6(2):70.
Dhor:—India, Cent. Prov. Barber Studies 3.
Dhori:—India, Watts' Dict. 6(2):70.
Dhour:—Java, from English India, Kohus, Med. 48, 1893.
Dhoura:—North India, Barnes.
Dhur:—Cent. India, Watts' Dict. 6(2):69.
D. I.:—(As initials with numbers.) See Demak Idjo.
Diamond:—(With numbers) refers to seedlings grown at the Diamond Plantations, Brit. Guiana.
Diard:—Mauritius, from Java. 1850, Dept. Ag. Bull. 2:5 & 11, 1916. Queensland, from Mauritius 1870. J. Hill Java, from Malacca, Wakker, 1896. Porto Rico, Stahl, 1880. López Tuero, who notes several kinds of Diard. = Black Cheribon, Deerr. Named for the man who sent these canes from Java to Reunión and Mauritius at the time of the first outbreak of disease. The name seems to be equal to Cheribon and to include the three-color forms.
Diard Rayée:— = Striped Cheribon, Deerr.
Diard Rose:—Queensland, from Mauritius, 1874, Easterby.
Dikehan:—India, N. W. Prov., Watts' Dict. 6(2):62.
Divisao:—Pernambuco, Brazil, Bull. 3. = Canna de Beija Flor. = Roxa.
Djamprik:—Java, from Java, Wakker, 1896. Soltwedel, fig. 16. The plate represents a slender, dark-purple cane with surface craking; nodes not constructed, cylindrical; buds large ovate. One is developed into a leafy shoot to show the purplish leaves. Argentine, = Venagre de Sao Simao. [= Etam obat.]
Djandjan:—Java, from Borneo, Wakker, 1896.
Djapara:—Java, Vanderventer, Handb. 5:134, 1915. [See Japara.]
Djawa:—Java, from Sumatra, Wakker, 1896.
Djoeng Djoeng:—Mauritius, from Java, 1869, Horne, Striped. Queensland, from Java, Davidson. 1880, = Green Ribbon. (Spelled Djioeng Djioeng.) Susceptable to gum disease, E. F. Smith. Java, from Sumatra, Wakker, 1896.
Djogoeng:—Java, from Sumatra, Wakker, 1896.
Djomba-Coure:—New Caledonia, Breslau 1884, Sagot 332.
Djong Djong:—Queensland, from Java, Arch. 1. Ap. 1892. [See Djoeng Djoeng.] Java, from Australia, Wakker, 1896.
Djoombakomay:—Java, from New Caledonia, Wakker, 1896.
Dogangueni:—New Caledonia, Vieillard, 1863, Sagot 348.
Dolhu:—Java, from English India, Kobus, Med. 48, 1893.
Domo:—New Caledonia, Breslau 1884, Sagot 340.
Don Caetona:—Argentine, from Brazil, Zerban, 1910.
Dooma:—Queensland, from Fiji, 1878, Easterby.
Do-omo:—Mauritius, from New Caledonia, Lavignac 1870, Horne.
Dora Batu:—Queensland, from Fiji, 1878, Easterby.
Dora Kaili:—Queensland, from Fiji. 1878, Easterby.
Dora Kenta:—Queensland, from Fiji. 1878, Easterby.
Dora Lu Lu:—Queensland, from Fiji, 1878, Easterby.
Dora Mai Mai:—Queensland, from Fiji, 1878, Easterby.

Dora Siga:—Queensland, from Fiji, 1878, Easterby.
Dora Tamati:—Queensland, from Fiji, 1878, Easte-by.
Dora Vies:—Queensland, from Fiji, 1878, Easterby.
Dora Von Von:—Queensland, from Fiji, 1878, Easterby.
Douwn Merah:—Java, from Hawaii, Wakker, 1896.
Dr. Caetano:—Bahía, Brazil. The Sugar Cane 22:483, 1890. [See Don Caetona.]
Egg Cane:—Wray. See Tibboo Teeloor.
Egipcia Ambar:—Argentine, Tucuman Rev. 5. (5): 209, 1914. [See Java 105 P. O. J.]
Egipcia Morada:—Argentine, Rev. 5, 209, 1914. = Louisiana Purple, Rev. 9:130. [= Black Cheribon.]
Egipcia Rayada:—Argentine, Rev. 5:209, 1914. = Louisiana Striped, Rev 9:130. [= Striped Cheribon.]
Egyptian:—Mauritius (from Egypt), Horne 1869. Jamaica, D. Morris, The Sugar Cane 17:153, 1885. Dark Purple, adapted for dry regions. Jamaica. Bot. Dept. Bull. 2, from Mauritius in 1882, Striped Green. [Evidently a mixture under this name in Jamaica.]
Eikur:—India, Watts' Dict. 6(2): 67.
E. K.:—(As initials with numbers) Java, seedlings made by E. Karthans by crossing Fidji as staminate on Bandjermassin hetan as mother, Jeswit, Med. 8, 1917.
Ekar:—India, Dict. 6(2): 66. Barber, Studies 2 & 3. Also The Sugar Cane. 15: 594 & 644 1883
Elephant:—Annam. Cochin-China, = Mia Voi, The Sugar Cane 11, 118, 1869. Mysore, Ag. Cal. 1915 Hawaii, Deerr & Eckert. Demorara, Harrison & Jenman Demorara, from Jamaica, Harrison & Jenman, noted as quite distinct from true Elephant. Jamaica, Jamaica Bot. Bull. 2. Guadaloupe, The Sugar Cane 4:274 & 605, 1872. Queensland, from Mauritius 1878, Easterby. = Teboe Gladjah, Deerr.
Elephante:—Porto Rico, López Tuero = Gigante.
Encertada, or Junction:—Brazil, The Sugar Cane 25:187, 1893. [A supposed graft-hybred.]
Envernizada:—Brazil, = Manteiga. Deerr.
Escambine:—(With numbers) Queensland, from Mauritius, 1901, Easterby. [See Iscambine.]
Escossia Sao Simao:—Argentine, from Brazil, Zerban 1910.
Esimbic:—Louisiana, from Jamaica, Agee. [See Tsimbic.]
Española:—Argentine, from Brazil, Zerban, 1910. [= Creole.]
Etam (Tibboo Etam):—Straights Settlements Wray. Queensland, from Batavia, 1878, Easterby. = Black Cheribon Deerr. The word Etam, Etem, Hetem or Hetam as it is variously spelled a Malay word meaning black, occurs in many cane names.
Etam Obat:— = Medicine Cane, Wray, leaves purple. [= Djamprik.]
F.:—(As initial following numbers) Java, = Fabri, Ledebour. Med. 4:452, 1917.

F. A. C. C.:—(As initials with numbers) Barbados, Rept. 1917–19: 60, 1919. No explanation.
Fairymead:—Queensland, Easterby = D 1135.
Fary-Ahomber:—Madagascar, sent to Mauritius Bot. Gar. in 1813–16, Thompson. See Watts' Dict. 6(2): 41–8.
Fary-Andrafaw:—Madagascar, sent to Mauritius Bot. Gar. 1813–16, Thompson. See Watts' Dict. 6(2): 41–8.
Fary-Androwfaw Mayna:—Madagascar, sent to Mauritius Bot. Gar. 1813–16, Thompson. See Watts' Dict. 6(2): 41–8.
Fary-Baymayvow:—Madagascar, sent to Mauritius Bot. Gar. 1813–16, Thompson. See Watts' Dict. 6(2): 41–8.
Fary-Boubaya:—Madagascar, sent to Mauritius Bot. Gar. 1813–16, Thompson. See Watts' Dict. 6(2): 41–8.
Fary-Carang:—Madagascar, sent to Mauritius Bot. Gar. 1813–16. Thompson. See Watts' Dict. 6(2): 41–8.
Fary-Corowh:—Madagascar, sent to Mauritius Bot. Gar. 1813–16, Thompson. See Watts' Dict. 6(2): 41–8.
Fary-Feesweet:—Madagascar, sent to Mauritius Bot. Gar. 1813–16, Thompson. See Watts' Dict. 6(2): 41–8.
Fary-Maeritee:—Madagascar, sent to Mauritius Bot. Gar. 1813–16, Thompson. See Watts' Dict. 6(2): 41–8.
Fary-Mang-Indavalan:—Madagascar, sent to Mauritius Bot. Gar. 1813–16, Thompson. See Watts' Dict. 6(2): 41–8.
Fary-Voulon:—Madagascar, sent to Mauritius Bot. Gar. 1813–16, Thompson. See Watts' Dict. 6(2): 41–8.
F. C.:—(As initials with numbers) Porto Rico, = Fajardo Central Seedlings.
Ferrea:—Argentine, from Brazil, Zerban, 1910. = Cavengirie, Deerr.
Fiambo:—Mauritius, Rept. 1896. Argentine, from Brazil, Zerban, 1910. [See Tsiambo.]
Fiji:—Java, (also spelled Fidji and Fidsji) = Canne Mort, immune to Sereh. Used by Bruicius and others in making crosses. Frequently mentioned, especially in Java literature.
Fiji B.:—India, Barber, Studies 2.
Fiji Bamboe:—Java, Kobus, Med. 6, 1893.
Fiji Geel:—Java, Kobus, Med. 6, 1893.
Fiji Geel Gestreipt:—Java, Kobus, Med. 6, 1893.
Fiji Koening:—Java, Moquette, Arch. 6: 301, 1898. =Canne Mort.
Fiji Rayée:—Mauritius, Boname Rept. 1895, 1896; badly attacked by Gum Disease, 1898–9.
Fiji Ribbon:—Australia, Melmouth Hall, The Sugar Cane 6: 588, 1874.
Fiji Zwart Gestreipt:—Java, Kobus, Med 6, 1893.
Fistula de Sao Simao:—Argentine, from Brazil, Zerban 1910. See Morada del País [Black Cheribon].
F. J. C.:—(Initials with numbers) Barbados, Rept. 1917–19; 60, 1919.
Flor de Brazil:—Brazil, Gorkum, 1915.
Flor de Cuba:—Brazil, = Manteiga, Deerr.

Formosa:—Philippines, Agr. Rev. 6: 618, 1913.
Foster's Seedling:—Trinidad, Bull. 18, 73, 1919.
Fotiogo:—Mauritius, Boname, Rept. 1895. Agr. Bull. 2: 5, 1916. Introduced from New Caledonia about 1870. So. Africa, from Mauritius, Choles.
Fraser:—Mauritius, Boname Rept. 1898–9.
Frijoe:—Java, from Borneo, Wakker 1896, West-Java Geerligs Med. 27.
Frost Resister:—Australia, Easterby, = D 1135.
Fudburi:—Bombay, India, Knight.
Función:—Bahía, Brazil, The Sugar Cane 22: 83, 1890.
Gabrasdali:—Bombay, India, Watts' Dict. 6(2): 73.
Gadenadeboui:—New Caledonia, Vieillard, 1863, Sagot 346.
Gading:—Java, Borneo, Sumatra, Wakker, 1896.
Gadjah:—Java, from Java, Malacca, Wakker, 1896. Soltwedel, fig. 7. This represents a stout green cane much blackened by Sooty Mould; internodes medium short, enlarged above, not staggard; nodes prominent; buds ovate, divergent. = Elephant, Deerr.
Gadmghetoel:—Java, from Borneo, Wakker, 1896.
Gagak:—Java, from Sumatra, Wakker, 1896; Kobus, 1893.
Galaga:—(With numbers) Queensland, from Mauritius, 1901, Easterby.
Galaga C:—Mauritius Boname, Rept. 1895, 1898–9.
Galaga M:—Mauritius Boname, Rept. 1895, 1898–9.
Galoengoeng:—Java, from Sumatra, Wakker, 1896.
Galogo C:—Queensland, from Mauritius, 1902, Easterby, Maxwell Rept. 1903–4. [See Galaga.]
Ganda Cheni:—Maysore, Barber Studies 3.
Ganna:—India, a class name, S. M. Hadi, Deerr. Includes Uba, Barber. Int. Sug. Jour. Jan. 1918.
Garei:—Java, from Sumatra, Wakker, 1896.
Garig:—Queensland, from Louisiana, 1895, Easterby. Louisiana Stubbs; a dark-striped bud sport.
Gawar:—Java, from Borneo, Wakker, 1896.
G. C.:—(As initials with number) Porto Rico = Seedlings grown at Guánica Centrale. Barbados, Rept. 1911–13: 57, 1913, doubtless also refers to these Guánica Seedlings.
Gee Gow:—Hawaii, Eckert. Bull. 10: 7, 1905.
Geel:—Java, from Manila, Wakker, 1896.
Geel Duitsch N. Guinea:—Java, Welbrink & Ledebroer, Med. 6: 86. Harreveld, Med. 12; 1745, 1918.
Geel Gestreipt Batjan:—Java, Welbrink & Ledebroer, Med. 6: 86, 1911.
Geel Muntok:—Java, Harreveld, Med. 13: 216, 1918.
Geel Paramaribo:—Java, Geerligs, Med. West-Java 27.
Geel Shamshara:—Java, from Calcutta, Kobus, Med. 48, 1893.
Gending Soerat:—Java, Kobus, Med. 6, 1893.
Geolo Mila:—Queensland, from Fiji, 1878, Easterby.
Gestreipt Cheribon:—Java, Wilbrink & Ledebroer, Med. 6: 86, 1911. [See Striped Cheribon.]

Gestreipt Fidji:—Java, Geerligs, West Java, Med. 27
Gestreipt Mappoe:—Java, Geerligs, West Java, Med. 27.
Gestreipt Muntok:—Java, Harreveld, Med. 13: 216, 1918.
Gestreipt Preanger:—Java Harreveld; Van Derventer, Handb. 5: 145, 1915.
Gigante:—Porto Rico Stahl, 1880; López Tuero, = Elefante.
Gingham:—Mauritius, Queensland. [See Guingham.]
Gingila:—Queensland, Easterby. A supposed graft-cross between Mauritius Guingham and Badilla.
Gingor:—Queensland, Easterby. A supposed graft-cross between Mauritius Guingham and Goru.
Gingraya:—Queensland, Easterby. A supposed graft cross between Mauritius Guingham and Oraya.
Glagah:—Java, from Java, Wakker, 1896. Teboe Glagah, Soltwedel, fig. 27. The plate represents a very slender, grass-like, green cane, the wild *Sac spontaneum* of Java. Immune to Sereh, E. F. Smith Bact. 3: 76.
Glonggong:—Java, from Java, Wakker, 1896. Teboe Glonggong, Soltwedel, fig. 26. The plate represents a slender green, reed-like cane with only one row of rudimentary roots. = *Sac. Soltwedeli* Kobus. Arch. 1: 17, 1893. Immune to Sereh, E. F. Smith, Bact. 3: 76.
Gloreale:—New Caledonia, Vieillard, 1863, Sagot 345.
Goat Shank:—Jamaica. See Selangore.
Goela:—Java, from Sumatra, Wakker, 1896. Teboe Goela, Soltwedel, fig. 1. This plate represents an entire hill of cane, so detail is not given. It is a dark, reddish-purple, upright cane resembling Cavengirie. It is suggested in the text that it may be the same as Teboe Gagak.
Gogari:—Queensland, from New Guinea as No. 8a, Maxwell, Easterby, Deerr.
Goi Goi:—Queensland, from New Guinea as No. 42, Easterby. Called Palmyra in Mackay district. Introduced in 1896.
Goja:—Java, from Sumatra, Wakker, 1896.
Gold Dust:—So. Africa, Choles. [See Polvo de Oro.]
Gondang:—Java, from Sumatra, Wakker, 1896.
Gonzalves:—Java, = Black Cheribon, Deerr.
Gorn:—Barbados, Rept. 1910–12: 101. [See Goru.]
Goru:—Queensland, from New Guinea as No. 24, 1896, Easterby.
Goru Bunu Bunana:—Queensland, from New Guinea as No. 24b, Easterby, Maxwell. Mauritius, from Queensland, Bull. 22 1910.
Goru Possi Possana:—Queensland, from New Guinea as No. 24, Maxwell, Easterby, Deerr. Mauritius, from Queensland, Bull. 22, 1910.
Goru Scela Scelana:—Queensland, from New Guinea as No. 24A, Maxwell, Deerr. Mauritius, from Queensland, Bull. 22, 1910.
Governo de Sao Simao:—Argentine, from Brazil, Zerban, 1910.
Governor:—Jamaica, Sug. Sta. Rept. 2: 62, 1908.
Governor Lees:—Demorara, Harrison & Jenman.
Graine Ch. Blanche:—Mauritius, Boname, Rept. 1898–9.

Graine Ch. Rouge:—Mauritius, Boname, Rept. 1898–9.
Graine Rouge:—Mauritius, Boname, Rept. 1898–9. [See Canne Graine.]
Grande Savanne:—Jamaica, from Mauritius, 1882, D. Morris. Demorara, Harrison & Jenman. Louisiana, from Jamaica, Stubbs, Agee. [The name seems to have originated in Jamaica.]
Grankay:—Queensland, from Mauritius, 1878, Easterby.
Grassy Black:—Bombay, India, Knight Bull. 61, 1914.
Gray Fiji:—Australia, from Fiji in 1866 by O. O. Danger, Melmouth Hall, The Sugar Cane 6:588, 1874.
Green:—Louisiana, = Crystalina, Stubbs, Deerr.
Green and Yellow:—Java, from Malacca, Wakker, 1896. Queensland, from Mauritius, 1878, Easterby.
Green Bamboo:—Queensland, from Mauritius, 1878, Easterby.
Green Brisbane:—Jamaica, from Mauritius, 1882, D. Morris. [See Green or Yellow.]
Green Cane:—Georgia, Florida, = Otaheite, Yoder, U. S. Dept. Agr. Bull. 486.
Green Diard:—Queensland, from Mauritius, Davidson, 1880. "Cane itch strong." [The Diard Canes are usually supposed to = Cheribon, but this cannot be one of them.]
Green Dupont:—Queensland, 1878, Easterby; a supposed sport from Daniel Dupont. [= Yellow Caledonia.] Resistant to Gum Disease, E. F. Smith, Bact. 3:69.
Green Elephant:—Louisiana, from Jamaica, Stubbs, Agee.
Green Natal:—So. Africa, Chole, = Umoba.
Green or Yellow:—Australia, Brisbane Bot. Gar. 1870, from New Caledonia. The Sugar Cane 2:104, 1870. [See Green Brisbane.]
Green Ribbon:—Louisiana, Fleishman, 1848, with colored plate. Georgia, Florida, = Simpson in Fla. Yoder. Queensland, = Djoeng Djoeng, Davidson. Demorara, = Melay, Brisbane, Harrison & Jenman, = Green Rose Ribbon, Deerr. [= A white striped sport of Otaheite. = Imperial de Brazil.]
Green Rose Ribbon:—Jamaica, introduced from Mauritius, 1882, D. Morris. Louisiana, from Jamaica, = Malay, Brisbane, Stubbs, = Green Ribbon, Malay, Brisbane, White Striped Bourbon, Louzier Rayée; it is a striped sport from Otaheite Deerr. [This name seems to have started in Jamaica.]
Green Salangore:—Trinidad; provisional name proposed by Mr. Purdie, The Sugar Cane 11:585, 1879.
Green Striped:—Louisiana, from Jamaica, Agee. [= Green Ribbon?.]
Green Striped Lousier:—Mauritius, as a sport from Lousier Dept. Agr. Bull. 2:11, 1916. [= Green Ribbon.]
Green Tanna:—Queensland, from Mauritius in 1878, = Malabar, Easterby. Mauritius, from N. S. Wales, 1895, = White Tanna, Dept. Agr. Bull. 2:11, 1916. [= Yellow Caledonia.]
Green Transparent:—Demorara, West Ind. Bull. 5:344, 1905. = Selangore, Deerr.

Greet:—Java, from Sumatra, Wakker, 1896.
Groen (dun):—Java, from Dutch New Guinea, Wakker, 1896.
Groen Batjan:—Java, Wilbrink & Ledebroer, Med. 6:86, 1911.
Groen Duitsch N. Guinea:—Java, Wilbrink & Ledebroer, Med. 6:86, 1911.
Grosse Blanche:—Mauritius, Boname, Rept. 1895, 1898–9.
Grosse Verte de Taití:—Jamaica, Tussac, 1808, pl. 25, fig. 1. The plate represents a green, strongly zigzag cane about 1⅛ inches in diameter; nodes prominente; rudimentary roots large, in three rows; glaucous band well marked, growth ring broad, whitish.
Grosse Violette de Taití:—Jamaica, Tussac. 1898, pl. 25, fig. 3. The plate probably represents Black Cheribon, though if so the drawing is not good and the diameter is too great as compared with Otaheite which is also figured.
Grossona:—Brazil. See Cinjenta, Deerr.
Gros Ventri:—Queensland, from Mauritius, 1878, Easterby.
G. T. C.:—(As initials with numbers) Barbados, Rept. 1917–19; 60.
Guana Cane:—[Guiana] Mauritius. See Jamaica Cane, 1869, Horne.
Gubbi Rasdali:—Bombay, India. See Punda, Knight.
Guinabhi:—Mauritius, from New Caledonia (Lavignac), 1869, Horne.
Ghewora-tu:—India, Watts' Dict. 6(2): 66.
Ghorru:—India, Watts' Dict. 6(2): 67.
Guiname:—Mauritius, from New Caledonia (Lavignac), 1869, Horne.
Guinapa:—Queensland, from So. Sea Islands, 1874, Easterby.
Guinapassa:—Mauritius, from New Caledonia (Lavignac), Horne, 1869.
Guingan:—Porto Rico, Stahl, 1880. [= Guingham.]
Guingham:—Porto Rico, López Tuero, according to Deerr = Big Ribbon = Striped Tanna. See also Gingham. [The name has also often been applied to striped Cheribon.]
Guinham:—Queensland, from Mauritius, 1874, Easterby. [= Guingham.]
Gundgire:—India, Watts' Dict. 6(2): 72.
Guyane:—Mauritius, Horne, 1869. [Cayane?.]
G. Z.:—(As initials with numbers) Java, = Zaadriet Generation = Seedling. In the Java literature often used before numbers with P. O. J., B, or other letters following.
Habanera:—Mexico. See Caña Violeta de Batavia. [= Djamprik.]
Haboel:—Java, from Sumatra, Wakker, 1896.
Hambledon:—Argentine, from Queensland as No. 426, Rev. Tucuman, 9(1): 14, 1918.
Hanara:—India, Watts' Dict. 6(2): 66.
Hanau:—Java, from Riouw, Wakker, 1896.
Hannays No. 2:—Barbados, Rept. 1907–9: 87.
Hapoei:—Java, from Sumatra, Wakker, 1896.
Hard Red:—Bombay, India, Knight, Bull. 61, 1914. = Songada Rati.
Hard Striped:—Bombay, India, Knight, Bull. 61, 1914. = Bangadya.

Harong:—Java, from Sumatra, Wakker, 1896.
Harrison:—Demorara, Harrison & Jenman.
Hatch:—Queensland, from Java, 1878, Easterby.
Hauer:—Mauritius, from Java, Horne, 1869. Queensland, from Java, 1874, Easterby.
Hauer Mheera:—Mauritius, from Java, Horne, 1869.
Haw:—(With numbers) Barbados, Rept. 1913–15: 55.
Hawe:—Java, from Sumatra, Wakker, 1896.
Hemja:—India, Taylor, Woodhouse, Clark & Hadi.
Heywoods Seedling:—Barbados, Rept. 1905–7: 36, 1808.
Hillii:—Jamaica, from Mauritius, 1882, D. Morris. Demorara, Harrison & Jenman.
Hill's Seedling:—Trinidad, Bull. 18: 37, 1919.
Hitam:—Java, from Sumatra, Wakker, 1896. [Hitam, Hitem, Itam and Item all mean black.]
Hitam Broewang:—Java, from Borneo, Wakker, 1896.
Hitam Kalampi:—Java, from Borneo, Wakker, 1896.
Hitam Siam:—Java, from Borneo, Wakker, 1896.
Hitan:—Queensland, from New Guinea as No. 41, 1896, Easterby. [= Hitam.]
Hitem:—Java, from Sumatra, Wakker, 1896.
Hitem Dadak:—Java, from Borneo, Wakker, 1896. See Tibu Item Borneo, Kruger.
Hoeloe:—Java, from Sumatra, Wakker, 1896.
Home Purple:—Queensland, from Louisiana, 1895, Easterby. [= Black Cheribon.]
Home Ribbon:—Louisiana, = Red Ribbon, Stubbs, Striped Cheribon, Deerr.
Home Striped:—Queensland, from Louisiana, 1895, Easterby. [= Striped Cheribon.]
Honderdbruin:—Java, = 100 B, Harreveld, Med. 15: 1597, 1917.
Hondurus:—Argentine, from Brazil, Zerban, 1910.
Hong Kong Socrat:—Java, Kobus, Med. 6: 1893.
Honolulu:—Demorara, Harrison & Jenman.
Honuaula:—Hawaii, Eckert, Bull. 17: 9, 1906. Louisiana, from Hawaii, Stubbs = Ohia, = Papaa.
Hope:—Jamaica, Bot. Bull. 2; Louisiana, from Jamaica, = Crystalina, Stubbs.
Horne:—Jamaica, from Mauritius, 1882, D. Morris. Demorara, Harrison and Jenman. Louisiana, from Jamaica, Stubbs, 1896. Mauritius, = Louzier Rayée, a striped sport from Louzier, Deerr. [A red-striped form of Otaheite.]
Hotte Cheni:—Mysore, India, Barber, Studies 3.
H. D.:—(As initials with numbers) Queensland. = Seedlings produced at the Hambledon Estate, Queensland by the Colonial Sugar Ref. Co. 1901 to 1905, after which seedling work was transferred to Fiji, Easterby.
Hullu:—Madras, India, Barber, Studies 3.
Hullu Kabbu:—India, Barber, Studies 2.
Hurong:—Java, from Sumatra, Wakker, 1896.

Husbands:—Barbados; a red cane sport, Rept. 1905–7: 34, 1908.
H. V. A.:—(Initials with numbers) Java, Kuijper, Med. 5, 1919.
Hybrid Footisgoo:—Queensland, from Mauritius, 1901, Easterby.
Hybrid Galaga:—Queensland, from Mauritius, 1901, Easterby.
Idjo:—Java, from Java, Wakker, 1896.
Idjoe:—Java, from Cochin China, Wakker, 1896.
Idjo Hongkong:—Java, Soltwedel fig. 29. The plate represents a slender long-jointed green cane with swollen nodes and very broad but indistinct growth ring. Probably a form of *Sac. Spontaneum.*
Idjo Kaliwoengoe:—Oost-Java, Med. 47.
Imperial:—Jamaica, = Violet Cane, MacFadyen [= Black Cheribon]. Queensland, from Mauritius, 1877, resembles Guingham, Easterby [= Striped Tanna]. Brazil, a green-and-yellow striped cane, Deerr. Argentine, from Brazil, Zerban, susceptible to Gum Disease, E. F. Smith. [= Green Ribbon.]
Imperial del Brazil:—Porto Rico. = Carandali, Calancana, Stahl. López Tuero. [= Green Ribbon.]
Inalmon:—Philippines. = Black Manilia, Hines, Agr. Rev. 8: 153, 1915.
Induari:—Queensland, from New Guinea, Maxwell, Easterby.
Induria:—N. S. Wales, Int. Sug. Jour. 1: 506, 1899.
India:—Argentine, from Brazil, Zerban, 1910.
India de Jujuy:—Argentine, a plantation name for a mixture of Criolla Blanca [= Crystalina] and Verde de Jujuy [= Otaheite] Fawcett, Rev. 9: 135, 1919.
Inglesa:—Porto Rico, Stahl, = Otaheite.
Innis:—(With numbers) Queensland, from Mauritius, 1901, Easterby.
Irimotu:—Society Islands, Cruzent, 1860, = *Sac. fragile.* Tahiti, Bennett, The Sugar Cane 6: 593, 1874. = Yellow Tahitian [not Otaheite].
Iscambine:—Mauritius, from New Caledonia, 1870, Dept. Agr. Bull. 2: 5 & 11, 1916. Iscambine Canes, Deerr, the Striped Iscambine = Tsimbec, from New Caledonia. Iscambine Rouge is a sport from the striped.
Iscambine Rayée:—Mauritius, Boname, Rept. 1895, 1898–9.
Iscambine Rouge:—Mauritius, Boname, Rept. 1895, 1898–9.
Ischiemie:—Queensland, from New Caledonia (Caldwell), Davidson, 1880, from So. Sea Islands, 1874, Easterby. [Seems to be a misprint for Ischambine.]
Ischikanemba:—Mauritius, from New Caledonia (Lavignac), Horne, 1869.
Isumba:—Mauritius, from New Caledonia (Lavignac), Horne, 1869.
Itam:—Mauritius, from Java, Horne, 1869. [See Hitam.] = Black Cheribon. Java, = Monjet de Cheribon, Krajenbrink, The Sugar Cane 2: 190, 1870.
Itam Klampei:—Java, from Borneo, Geerligs, West-Java, Med. 27.
Item:—Java, Gonzalves, = Black Cheribon. Java, from Sumatra, Wakker, 1896.

Item Billiton:—Java, Wilbrink & Ledebroer, Med. 6:86, 1911.
J.:—(Initial with numbers) Jamaica Seedling canes.
Jaganathia:—India, Barber, Studies 3.
J. A. M.:—(Initial with numbers) Barbados Rept. 1917–19: 60.
Jamaica:—Barbados, = Mont Blanc [Crystalina], Rept. 1902. Demorara, = Po-a-ole [Cavengirie], Harrison & Jenman. Mauritius, = Guiana [Otaheite], Horne, 1869.
Jamaica Amarilla:—Peru, = Otaheite, Zerban, Rev. Tuc. 1:29, 1910.
Jamaica Elephant:—Demorara, Rept. 1894–5.
Jamaica Transparent:—See Elephant, Bull. 4:227, 1897.
Japanese:—Louisiana, Agee, [= Zwenga].
Japara:—Java, from Java, Wakker, 1896.
Japara Njamplong:—Java, Kobus, Med. 6, 1893.
Jappara Djawa:—Sagot 330, 1893.
Japparah Bali:—Sagot 329, 1893.
Japparah Bina:—Sagot 339, 1893.
Japparah Glagah:—Sagot 329, 1893; Java, Kobus, Med. 6, 1893.
Japparah Malan:—Sagot 330.
Jate:—New Caledonia, Vieillard, 1863, Sagot 347.
Java:—Louisiana, from Hawaii, Agee. Demorara, = Black Cheribon, Harrison & Jenman. Jamaica, Bot. Dept. Bull. 2. India, Barber, Studies 2. [Usually refers to the Cheribon canes.]
Jenman:—Demorara, Harrison & Jenman.
Jowari White:—Bombay, India, Knight. See Niliva.
Julian:—Argentine, from Brazil, Zerban. See Morado del País. [= Black Cheribon.]
J. V.:—(Initials with numbers) Java, Harreveld, Med. 3:1028, 1919.
Kabbu:—Madras, India, Barber, Studies 3.
Kabirya:—Bombay, India, Knight. = Ramrasdali.
Kabopolenounen:—New Caledonia, Vieillard, 1863, Sagot 345.
Kadi:—Bombay, India, Watts' Dict. 6(2): 73.
Kadjule:—Bengal, India, Watts' Dict. 6(2): 57. See also colored illustration published by East India Co. 1792.
Kaghze:—India, Barber, Studies 2, 3. See Kughaze, Watts' Dict. 6(2): 62.
Kagli:—India, Watts' Dict. 6(2): 57.
Kahi:—India, Barber, Studies 1. The native name for the wild cane *Sac. spontaneum;* "red or yellow; leaves narrow or broadish, sheaths spiney or smooth, circlet of hairs abundant or nearly absent; buds densely hairy to nearly glabrous, small and placed low down on joint, to elongate and high up, &c.; juice 3 to 5 per cent sucrose. Crosses readily with cultivated kinds. Seedlings of cultivated kinds often throw back to this native type."
Kahu:—India, Watts' Dict. 6(2): 67. Barber, Studies 1. The Sugar Cane 15: 644, 1883.
Kaingyran:—Burma, Watts' Dict. 6(2): 78.
Kainio:—Louisiana, from Hawaii, Stubbs, Agee.
Kaiva:—India, Watts' Dict. 6(2): 60.
Kajali:—India, Watts' Dict. 6(2): 57, Bengal 60.
Kajla:—Java, from English India, Kobus, Med. 48, 1893.

Kajoole:—India, Roxburgh under *Sac. officinarum.*
Kakeo:—Mauritius, from Sandwich Isl., Horne, 1869.
Kakoe:—Jamaica, from Mauritius, 1882, D. Morris. [See above.]
Kakonakona:—Mauritius, from Sandwich Isls., Horne, 1869.
Kala:—Cent. India, Watts' Dict. 6(2):69, Bombay (Ozanne), p. 74. Used as a class name including various others.
Kalamboewei:—Java, from Sumatra, Wakker, 1896.
Kalariya:—India, Watts' Dict. 6(2):72.
Kali Gond Girri:—India, Watts' Dict. 6(2):70.
Kali Woengoe:—Java, Kobus, Med. 6, 1893.
Kalkhra:—Bombay, India, Barber, Studies 3.
Kalkya:—Bombay, India, Knight.
Kaludai Boothan:—India, Barber, Studies 2.
Kama:—Java, from Sumatra, Wakker, 1896.
Kamba-Kamba-Vati:—Demorara, Harrison & Jenman.
Kanangari:—Mauritius, from New Caledonia (Lavignac), Horne, 1869. [See also Kavarangri and Kavenger. New Caledonia; is this the original form of Kavangire or Cavengirie?]
Kanara:—India, Barber, Studies 1. North India, Barnes. The Sugar Cane 15:594 & 644, 1883.
Kansar:—India, Barber, Studies 1, 3. North India, Barnes.
Kansia:—India, Watts' Dict. 6(2):69, 70.
Kapoer:—Java, from Borneo, Sumatra, and Malacca, Wakker, 1896.
Kara Kabbu:—Bombay, India, Watts' Dict. 6(2):73.
Kara-Karawa:—Demorara, Harrison & Jenman.
Kare:—India, Watts' Dict. 6(2):73.
Kare Rasdali:—Bombay, Knight. See Tambada.
Karikarimbon:—Haití, mentioned by Tussac, 1808.
Karum:—India, Barber, Studies 2.
Kassoer:—Java, Kobus, Med. 6, 1893; Wakker, 1896; Wilbrink & Ledeboer Med. 6:86, 1911; E. F. Smith Bact. 3:76, immune to Sereh; Van Derventer, Handb. 5:129, 1915, a wild cane; Jeswit, with full desc. Med. 13:405, 1911.
Katara:—North India, Barnes.
Katarya:—India, Watts' Dict. 6(2):70.
Katha:—India, Barber, Studies 1, 2; North India, Barnes.
Kathia:—India, Watts' Dict. 6(2):67.
Katu:—Punjab, India, Watts' Dict. 6(2):66.
Kava:—Java, from Borneo, Wakker, 1896.
Kavangeri:—Bahía, Brazil, The Sugar Cane 22:483, 1890.
Kavangire:—Argentine, from Brazil, Zerban, 1910. Fawcett, = Uba, = Sin Nombre 54, = Bambu de Tabandi, Rev. Tucuman 9:144, 1919. With desc. & fig.
Kavangire de Santa Barbara:—Argentine, from Brazil, Zerban, 1910.
Kavangy:—Brazil, T. Weller, The Sugar Cane 25:187, 1893. [= Kavangire.]
Kavarangri:—New Caledonia, Breslau, 1884, Sagot 335. A large deep-red cane. [= Cavengerie?.]
Kavenger:—Mauritius, Boname Rept. 1898–99 = New Caledonia Queen. [= Cavengerie?.] See also Kanangari.

Kdam:—Cambodge, Sagot 326.
Keening:—Demorara, Harrison & Jenman, = Naga.
Kehkers:—Mauritius, from Java, Horne, 1869.
Kekarea:—Queensland, from New Guinea Maxwell, 1903–4.
Kelie:—Madras, India, C. A. Benson, Int. Sug. Jour. 2: 469, 1900.
Kemboeay:—Java, from Sumatra, Wakker, 1896.
Keni Keni:—Jamaica, from Mauritius, 1882, D. Morris. Demorara Harrison & Jenman = Nora Tava. Hawaii, Deerr & Eckert = Oudinot; Rock, Plant names, Bull. 2, 1913. Java, from Malacca, Wakker, 1896. Mauritius, Boname, Rept. 1896 & 1898–9. = Otaheite, Deerr.
Keong:—Java, from Java & Borneo, Wakker, 1896. Kruger with colored Plate No. 2 = Teboe Bessi Soltwedel Pl. 15, Teboe Keong. Soltwedel fig. 15. The plate represents a medium stout, dark-purple cane with surface cracks; nodes abruptly constructed blow the leaf scar, which shows a peculiar V-shaped folding; groove conspicuous; buds all strongly developed, said in the text to be a characteristic of the variety.
Kerah:—Java, from Sumatra, Wakker, 1896. E. F. Smith, Bact. 3: 77, immune to Sereh.
Ketar:—India, Papers, &c., Sugar, 3d Ap. 35, 1822, Watts' Dict. 6(2): 60.
Ketari:—India, Taylor, Woodhouse.
Keteki Puri:—Assam (Stack), Watts' Dict. 6(2): 62.
Kew Seedling No. 3:—Queensland, from Mauritius, 1901, Easterby.
Kewahi:—India, Cark & Hadi.
Kewali:—India, Taylor, Woodhouse.
Kewensis:—Queensland, from Kew Gardens, 1895, Easterby. E. F. Smith Bact. 3. Susc. to Gum Disease.
Khadkya:—Bombay, India, Watts' Dict. 6(2): 74.
Khadya:—Bombay, Barber, Studies 3; Knight Bull. 61, 1914.
Khagari:—Assam (Stack), Watts' Dict. 6(2): 62.
Khagri:—Bengal, Watts' Dict. 6(2): 60, Taylor, Woodhouse.
Khajla:—India, Watts' Dict. 6(2): 69; Woodhouse, possibly a degenerate Red Mauritius.
Khajuria:—Bombay, India, Knight, = Mewa or White Surati.
Khari:—India, Barber, Studies 2, 3; Barnes, Taylor, Woodhouse.
Khelia:—India, Barber, Studies 2; Taylor; Woodhouse.
Kiabone:—New Caledonia, Vieillard, 1863, Sagot 345.
Kiewahee:—India, Papers—Sugar, 1822.
Kikarea:—Queensland, from New Guinea, 1895, Easterby.
Kikil:—Java, from Sumatra, Wakker, 1896.
Kikir:—Java, from Sumatra, Wakker, 1896.
Kikir Andjing:—Java, from Sumatra, Wakker, 1896.
Ki Kon Oua:—New Caledonia, Breslau, 1884, Sagot 333.
Kilang:—Java, from Borneo, Sumatra, Wakker, 1896.
Kilkie:—Java, from Sumatra, Wakker, 1896.
Killie:—Java, from Malacca, Wakker, 1896.
Kinar:—North India, Barnes.
Kinemaite:—New Caledonia, Vieillard 1863, Sagot 345.

Kiong:—Mauritius, from Java, Horne, 1869.
Kirkirandjing:—Java, from Bovenlanden, Wakker, 1896.
Kirnya:—India, Watts' Dict. 6(2):57.
Kissaman:—Argentine, from Brazil, Zerban, 1910. = Morado del Brazil, = Cavengirie?
Kiwahi:—Benares, India, Watts' Dict. 6(2):57.
Klawoe:—Java, Harreveld, = Wit Manila.
Klidang:—Java, Geerligs, Med. West-Java 27.
Knox:—Mauritius, Boname, 1896, 1898–9.
Ko:—Hawaii, Rock, Plant names, Bull. 2, 1913. A native name for sugar cane in general.
Koeal:—Java, from Sumatra, Wakker, 1896.
Koembie:—Mauritius, from New Caledonia (Lavignac), Horne, 1869.
Koeng:—Oost-Java, Med. 7:4.
Koeng Bayowman:—Java, Kobus, Med. 5, 1893.
Koeng Sambas:—Java, Kobus, Med. 6, 1895.
Koening:—Mauritius, from Java, Horne, 1869. = Rappoe Koening. Java, from Fiji, New Guinea, Banka, Borneo, Wakker, 1896; Soltwedel, Teboe Koening, fig. 3. The plate represents a yellow, long-jointed cane of medium diameter, nodes somewhat constricted, rudimentary roots in 3 rows, furrow conspicuous for full length of internode; buds ovate. Looks much like Otaheite. Queensland, from Java, 1874, Easterby.
Koerik:—Java, from Sumatra, Wakker, 1896.
Koerik Solase:—Java, from Sumatra, Wakker, 1896.
Koering:—Java, from Sumatra, Wakker, 1896.
Koesoemo:—Java, Harreveld, Med. 15:1597, 1917. Jeswit, Med. 17: 34, 1917.
Koewal:—Java, from Sumatra, Wakker, 1896.
Koimbé:—New Caledonia, Breslau, 1884, Sagot 335.
Kokea:—Hawaii, Eckert, Bull. 17:9, 1906, Rock 1913. A greenish white native cane, Deerr. Louisiana from Hawaii, Stubbs, Agec. Queensland, from Hawaii, = Lahina, Easterby.
Kokeia:—Jamaica, from Mauritius, 1882, D. Morris. Java, from Malacca, Wakker, 1896.
Kondang:—Java, from Sumatra, Wakker, 1896.
Kondimona:—New Caledonia, Vieillard, 1863, Sagot 348.
Ko Pake:—Hawaii, = Cuban.
Ko-Poa-pa:—Jamaica, from Mauritius, 1882, D. Morris. Demorara, Harrison & Jenman.
Ko-Puaole:—Hawaii, Eckert, Bull. 17:9, 1906.
Koring:—Java, from Sumatra, Wakker, 1896.
Kossoer:—Oost-Java, Med. 47, 53.
Kotarea:—India, Watts' Dict. 6(2):70.
Koubala:—New Caledonia, Vieillard, 1863, Sagot 345.
Krebet:—(With numbers) Java, Harreveld, Med. 4:1654, 1919.
K. S.:—(With numbers) Java, Ledeboer, Med. 4:452, 1917.
Kuchhra:—India, Watts' Dict. 6(2):69.
Kuku Sari:—Queensland, from Fiji, 1878, Easterby.

Kullerah:—India, Watts' Dict. 6(2):57. Illustrated by East India Co. in 1792. A light-colored cane growing in swampy land. [The fact that different varieties are best adapted to special types of soil seems to have been better understood in 1792 than it is today.]
Kulloa:—Stubbs, Deerr. = Bamboo.
Kullooa:—India, Roxburgh, under *Sac. officinarum.*
Kullore:—India, Deerr, the first cane to be called Bamboo. [Do these last four names all refer to the same cane?]
Kumied Kala:—Punjab, India, Watts' Dict. 6(2):66.
Kumid Lahore:—Punjab, India, Watts' Dict. 6(2):66.
Kundiari:—India, Watts' Dict. 6(2):67.
Kuning:—Java, Krüger, 145 (see Soltw. III), = Tebu Teelor.
Kusha-tu:—Nepal, India, Watts' Dict. 6(2):66, = Kalo-zhenna.
Kuswar:—India, Clark & Hadi.
Kutara:—Java, from English-India, Kobus, Med. 49, 1893. India, Watts' Dict. 6(2):62.
Kutharee:—India, Papers—Sugar, Ap. 1:193, 1822.
Kutiar:—India, Watts' Dict. 6(2):67.
Kyannet:—Burma, Watts' Dict. 6(2):78.
Kyoukgoungyan:—Burma, Watts' Dict. 6(2):78.
Lahaina:—Hawaii (name from Lahaina plantation), from the Marquesas (Pardon Edwards), = Bourbon, Colony Cane, Otaheiti, Loucier, Portier, Bamboo II, China II, Cuban, Eckert; Bull. 10:4, 1905. Jamaica, from Mauritius, 1882, D. Morris. Demorara, Harrison, Java, from Malacca, Wakker, 1896. Mauritius, Boname, 1895. Argentine, Fawcett Rev. 9:138, 1919 with desc. & fig.
Lahi:—Hawaii, Rock, = Ko, a native name for sugar cane.
Lahira:—Java, Kobus, Med. 6:1893.
Lahria:—Java, from Malacca, Wakker, 1896.
Lakona:—Jamaica, from Mauritius 1882, D. Morris. Demorara, Harrison & Jenman, = Sacuri. Java, from Malacca, Wakker, 1896. Louisiana, from Jamaica, Stubbs, Agee. [The name seems to start in Jamaica.]
Lal:—North India, Barnes.
Lalanjore:—Brazil, Pernambuco, E. F. Smith, resistant to Gum Disease.
Lalgainra:—Bengal India (Chapman), Watts' Dict. 6(2):60.
Lalri:—India, Watts' Dict. 6(2):66; North India, Barnes; Barber, Studies 1 & 3.
Lamark:—Java, from Sumatra, Wakker, 1896.
Landjoeng:—Java, from Leouw, Wakker, 1896.
Lania:—Queensland, unknown origin, 1878, Easterby.
La Pice:—Louisiana, from Java, = Crystalina, Stubbs.
Laren:—Java, (from?), Wakker, 1896.
Large Green:—Demorara, Harrison & Jenman.
Lata:—India, Taylor, Woodhouse.
Laujón:—Java, from Malacca, Wakker, 1896.
Laukona:—Hawaii, Rock, = Ribbon Cane.

Ledoo:—India, Watts' Dict. 6(2):70. See also Ledu, p. 72, and Ledi, p. 67.
Leeut:—Tibboo Leeut, Straits Settlements, Wray, = Bourbon.
Lench:—Java, Kobus, Med. 6, 1893.
Le Sage:—Mauritius, Boname, 1895.
Le Sassier:—Louisiana, from Java, = Crystalina, Stubbs, Agee.
Lewari:—India, Taylor, Woodhouse.
Liat:—Java, from Sumatra and Billiton, Wakker, 1896.
Lielien:—Mauritius, from Java, Horne, 1869.
Lielium:—Australia, Brisbane Bot. Gar., from Java. The Sugar Cane 2:104, 1820.
Liembat:—Java, from Sumatra, Wakker, 1896.
Light Cheribon:—From Java, Deerr, = Blue, Burk, Crystalina, Green, Hope, La Pice, Le Sassier, Light Java, Mamuri, Mexican Bamboo, Mird, Mont Blanc, Naga B., Panachee, Rappoh, Rose Bamboo, White Transparent, Yellow Singapore.
Light Java:—Louisiana, from Jamaica, Stubbs, Agee, = Crystalina.
Light Purple:—Australia, Melmouth Hall, The Sugar Cane 6:588, 1874 [= Crystalina]; Int. Sug. Jour. 1:506, 1899. General planting permitted by Colonial Sug. Co.
Liguanea:—Jamaica, Bot. Bull. 2, Louisiana, from Jamaica, Stubbs, Agee. [Name seems to have originated in Jamaica.]
Lilien:—Queensland, from Java, Davidson, 1880; from Java, 1876, Easterby. [See Lielien.]
Lingga:—Java, from Sumatra, Wakker, 1896.
Lingga Koering:—Java, from Sumatra, Wakker, 1896.
Linggo of Gondang:—Java, from Sumatra, Wakker, 1896.
Listada:—Argentine, from Brazil, Zerban, 1910.
Listrado de Amarillo:—Brazil, = Roixa, Moreira, 1876.
Listrado de Roixo:—Brazil, = Solangor, Moreira, 1876.
Little Ribbon:—Australia, from New Caledonia, Angus Mackay, 1870.
Little Yellow:—Australia, from New Caledonia. Similar to Tabor Portii, from Java, Angus Mackay, 1870.
Loegoet:—Java, from Java, Wakker, 1896.
Loemar:—Java, from Borneo, Wakker, 1896.
Loemar Soerat:—Java, Kobus, Med. 6, 1893.
Loethers:—Java, from Mauritius, Wakker, 1896. Soltwedel, fig. 8. The plate represents a long-jointed, medium diameter, hazel-brown cane. In the text it states that when shaded it remains yellow-green; nodes prominent, rudimentary roots small in 2 to 3 rows, growth ring broad and conspicuous; buds ovate-triangular. [The name is supposed to be a corruption of Lousier, but in Java it has been applied to a cane quite distinct from Lousier. = Otaheite]; F. E. Smith, resistant to Sereh; Jeswit, Med. deel 6(13):383, 1916, full desc.
Loleba:—Java, from Amboina, Wakker, 1896.
Loma Loma:—Java, from Malacca, Wakker, 1896.
Lougil:—Queensland, from So. Sea Islands, 1878, Easterby.
Louisiana Purple:— = Black Cheribon.

Louisiana Ribbon:— = Striped Cheribon.
Louisiana Striped:— = Striped Cheribon.
Lousier:—(Also spelled Loucier and Lauzier) Mauritius, originating as a bud sport from the striped Mignone, Ag. Dept. Bull. 2: 11, 1916. It later sported again, giving rise to green-striped, red-striped and solid red forms. Indestinguishable from Otaheite, Deerr. Java, Kruger 142, T. 3. = Loethers [a brown cane]. Brazil, all citations = Cavengirie [evidently a mixing of labels]. Argentine, from Brazil, = Cavengirie.
Lousier da Mauricio:—Argentine, from Brazil, Zerban, 1910. Fawcett, Rev. 9: 137, 1919; agrees with Cavengirie except in color, is yellowish with faint purple striping on older joints.
Lousier Rayée:—Mauritius, Boname, 1895, 1898–9. = Green Rose Ribbon, Deerr.
Lousier Rayé Rouge:—Mauritius, Boname, 1898–9. = Horne, Deerr.
Lousier Rayé Verte:—Mauritius, Boname, 1898–9, = Green Rose Ribbon, Deerr.
Lousier Rouge:—Mauritius, Boname, 1898–9. Queensland, from Mauritius, Maxwell; Easterby.
Lugut:—Java, Kruger 141.
M.:—(As initial with numbers) Barbados Rept. 1915–17: 72, 1867. Queensland, = Mauritius seedlings, Easterby.
Mabuan:—Queensland, from New Guinea, Maxwell, Easterby.
Macao de Sao Simao:—Argentine, from Brazil, Zerban, 1910.
Machal:—India, Watts' Dict. 6(2): 71.
Macravati:—New Caledonia, Breslau, 1884, Sagot 339.
Madras Cane:—Burma, Watts' Dict. 6(2): 78.
Madras Seedlings:—India, Barber, Studies 2.
Magh:—Assam, Agr. Inst. Pusa, Bull. 83: 41, 1919.
Mahnoe:—Java, from Sumatra, Wakker, 1896.
Mahoaovu or Mavoe:—Queensland, from New Guinea, 1895, Easterby.
Mahoavi:—(With numbers) Queensland, from Mauritius, 1901, Easterby.
Mahona:—Queensland, from New Guinea as No. 22, 1896, Easterby.
Mailagir:—India, Watts' Dict. 6(2): 67.
Maillard:— = Striped Tanna, Deerr.
Maion:—New Caledonia, Vieillard, 1863, Sagot 345.
Majori:—Queensland, from Mauritius, 1878, Easterby.
Majori Perle:—Queensland, from Mauritius, 1878, Easterby.
Majori Rouge:—Queensland, from Mauritius, 1878, Easterby.
Makassar:—Java, Kobus, Med. 6, 1893; Van Derventer, Handb. 5: 151, 1915, imported in 1886.
Makassar Idjoe:—Java, Kobus, Med. 1893.
Makassar Soerat:—Java, Kobus, Med. 6, 1893.
Malabar:—Queensland, from Mauritius, 1874, Easterby, E. F. Smith, resistant to Gum Disease. = White Tanna, = Yellow Caledonia, Deerr.
Malabarde:—Porto Rico, López Tuero, 10, = Morada. [= Black Cheribon.]
Malaha:—India, Watts' Dict. 6(2): 62. = Magara or Megala.

Malaman:—Mauritius (from Java), Horne, 1869.
Malay:—Jamaica, Bot. Bull. 2. Louisiana, from Jamaica, Stubbs, Agee, = Green Rose Ribbon, Stubbs, Deerr.
Malawan:—Java, from Java, Wakker, 1896.
Maldo:—Java, from Sumatra, Wakker, 1896.
Malem:—Java, from Bali, Wakker, 1896.
Malgache:—Mauritius, Dept. Agr. Bull. 2:5, 1916. Queensland, with numbers, from Mauritius, 1901, Easterby.
Malmaman:—Queensland, from Java, 1874, Easterby.
Mam Blam:—Jamaica, Jour. Ag. Soc. 20:12, 1896, = Black Ribbon.
Mamendon:—Queensland, from So. Sea Islands, 1874, Easterby.
Mamuri:—Jamaica, from Mauritius, 1882, D. Morris. Demorara, = White Transparent, Harrison & Jenman. Java, from Malacca, Wakker, 1896. = Crystalina, Deerr.
Manau:—Java, from Sumatra, Wakker, 1896.
Manch of Basali:—North India, Barnes.
Maneria:—India, Taylor, Woodhouse, Barber, Studies 2.
Mangis:—Java, from Java, Wakker, 1896; Soltwedel, fig. 9. The plate represents a stout, reddish-brown, short-jointed cane; internodes straight, cylindrical; nodes prominent; buds large, irregularly ovate.
Mangis Idjo:—Java, from Java, Wakker, 1896; Soltwedel, fig. 6. The plate represents a medium stout, green cane with no flush; internodes straight, cylindrical, furrow slight; nodes not constricted, rudimentary roots in 3–4 rows, glauceus band strongly developed; buds large, broadly ovate.
Mangis Seloredjo:—Java, Kobus, Med. 6, 1893.
Mangis Soerat:—Java, from Java, Wakker, 1896.
Mangli:—Java, from Java, Wakker, 1896.
Mangli Betoel:—Java, from Java, Wakker, 1896.
Mangli Brangkal:—Java, Kobus, Med. 6, 1893.
Mangli Idjo Kendal:—Java, Kobus, Med. 6, 1893.
Mangli Soerat:—Java, Arch. 1. Ap. 1892.
Mango:—India, Papers—Sugar, 3d Ap. 35, 1822; Watts' Dict. 6(2): 57; Barnes, Taylor, Woodhouse.
Mani:—Demorara, = Norman, Harrison & Jenman.
Manigo:—India, Watts' Dict. 6(2): 60.
Manila:—Java, Kobus, Med. 6, 1893. E. F. Smith Bact. 3:77, resistant to Sereh.
Manteica de Sta. Bárbara:—Argentine, from Brazil, Zerban, 1910.
Manteiga:—Brazil, Pernambuco Station, Bull. 3; Gorkum 26, 1915. = Envernizada, = Calvacante, = Flor de Cuba, = San Pello, Deerr.
Manulete:—Hawaii, Eckert, Bull. 17: 9, 1906. Louisiana, from Hawaii, = Akilolo, Stubbs. Queensland, from Hawaii, 1880, Easterby.
Mapnoe:—Java, from Sumatra, Wakker, 1896.
Mapou:—Mauritius, Boname, 1895, 1898–9. Queensland, = Black Java, Easterby. Reunion, Colson.

Mapou Perle:—Brazil, Sao Paulo, Sawyer, 1908. Bahía, Brazil, The Sugar Cane 22:483, 1890. Argentine, from Brazil, Zerban, 1910.

Mapou Rayée:—Mauritius and Reunion, from New Caledonia, Sagot 328. Guadeloupe, Boname, 1888.

Mapou Rouge:—Brazil, Sao Paulo, Sawyer, 1908, Bahía, The Sugar Cane 22:483, 1890. Argentine, from Brazil, Zerban, 1910. Reunion (Delteil), Sagot 330.

Marabal:—(Usually spelled Marabel) Jamaica, from Mauritius, 1882, D. Morris. Louisiana, from Jamaica, Stubbs, Agee. Queensland, from Louisiana, 1895, Easterby.

Maracabo:—India, Papers—Sugar, Ap. 3:12, 1822.

Mara-Kabo:—India, Watts' Dict. 6(2):76.

Marnoe:—Java, from Sumatra, Wakker, 1896.

Maroe:—Java, from Borneo, Wakker, 1896.

Martinique:—Jamaica, Bot. Bull. 2. A slender white cane. The Sugar Cane 17:153, 1885. Article on the exhibit of 58 varieties of sugar cane, from Jamaica, at the New Orleans Exposition, a dark purple cane, adapted to dry regions. Island of Vieques, Porto Rico, a local name for a red cane, apparently = Black Cheribon. Also said to be a yellow Martinique cane there.

Mas:—Java, Geerligs, West-Java, Med 27.

Masiek:—Java, from Sumatra, Wakker, 1896.

Massambara:—Brazil, Weller, The Sugar Cane 25:187, 1893.

Massiek:—Java, Arch. 1. Ap. 1892.

Mataca:—Argentine, from Brazil, Zerban, 1910.

Matki Mango:—North India, Barnes.

Matna:—India, Watts' Dict. 6(2):62; North India, Barnes.

Mauritius:—Bengal, India, = Bourbon, Wray. India, from Mauritius, 1827. = Otaheite, Watts' Dict. 6(2):41. Java, from English-India, Kobus, Med. 48, 1893, brown-red, sheaths hairy [evidently not Otaheite]. Australia (Tryon) = Striped Guingham, susceptable to Gum Disease, E. F. Smith Bact. 3:69.

Mauritius Couve:—Queensland, Easterby.

Mauritius Diard:—Queensland, from Mauritius, 1878, Easterby.

Mauritius Guingham:—Queensland, from Mauritius, 1878, Easterby.

Mauritius Meerah:—Queensland, from Mauritius, 1878, Easterby.

Mauritius Ribbon:—N. S. Wales, Int. Sug. Jour. 1:506, 1899; planting permitted by Colonial Sug. Co. = Striped Cheribon, Deerr.

Mave:—Queensland, from New Guinea, = Nave, Maxwell, Easterby.

Mavoe:—Queensland, from New Guinea, = Mahoaovu, Maxwell, Easterby.

Mebouangué:—New Caledonia, Vieillard, 1863, Sagot 346.

Meera, or Meerah, or Merah:—A Malay word meaning red. In the literature the name usually refers to Black Cheribon, but probably other red or purple canes have been included. Java, Soltwedel, fig. 12, Teboe Merah. The plate represents a purplish red cane of medium diameter; buds broadly ovate and indicated as having a broad uniform margin. If intended for Black Cheribon the buds are badly drawn.

Meligeli:—Jamaica, from Mauritius, 1882, D. Morris. Demorara, = Bamboo I & II, Harrison & Jenman. Java, from Malacca, Wakker, 1896. [See Melegeli.]
Menado:—Java, Kobus, Med. 6, 1893.
Mendjalong:—Java, from Billiton, Wakker, 1896.
Mendku:—India, Watts' Dict. 6(2): 67.
Menoe:—Java, from Sumatra, Wakker, 1896.
Merah:—See Meera.
Merah Borneo:—Argentine. See Borneo.
Merati, or Merthi:—India, Watts' Dict. 6(2): 67.
Merd:—Usually written Tibboo Merd, = Crystalina, Stubbs, Deerr.
Merkuli:—India, Bengal (Chapman), Watts' Dict. 6(2): 60.
Merthi:—North India, Barnes.
Mesangan:—Punjab, India, Barber, Studies 3.
Mestiza:—Argentine, from Brazil, Zerban, 1910. Philippines, Agr. Rev. 6: 618, 1913.
Mewa:—Bombay, India, = Kajuria, Knight.
Mexican Bamboo:— = Crystalina, Deerr.
Mexican Ribbon:— = Louisiana Ribbon, John Diamond. [= Striped Cheribon.]
Mexican Striped:— = Red Ribbon, Stubbs. [Striped Cheribon.]
Mia Giang:—Java, from Cochin China, Geerligs, West-Java, Med. 27.
Mia-lan:—Cochin China, Sagot 326.
Mia May:—Java, from Cochin China, Geerligs, West-Java, Med. 27.
Mia Toa Dja:—Java, from Cochin China, Geerligs, West-Java, Med. 27.
Mia Voy:—Cochin China, = Elephant, The Sugar Cane 4: 605, 1872.
Migao:—New Caledonia, Vieillard, 1863, Sagot 345.
Mignonne:—Mauritius, from New Caledonia, 1870, Agr. Bull. 2: 11, 1916, Boname, 1895, 1898–9. [The cane from which Lousier is said to be a sport.]
Mignonne Rayée:—Mauritius and Reunion, from New Caledonia (Delteil), Sagot 328. Guadaloupe, Boname, 1888. Reunion, Colson, 1905.
Mignonne Rouge:—Mauritius, Boname, 1898–9.
Mirah Rubia:—Queensland, from Java, 1878. Easterby [misprint for Merah.]
Mirati:—India, Watts' Dict. 6(2): 66.
Mittan:—India, Watts' Dict. 6(2): 62.
M-ma:—Mauritius, from New Caledonia (Lavignac), 1870, Horne, 1869. Australia Davidson, Easterby, = Black Cheribon.
M-Merai:—Mauritius, from New Caledonia (Lavignac), 1870, Horne, 1869. Queensland, from So. Sea Islands, 1874, Easterby.
Mobona:—Louisiana, Agee.
Moene:—New Caledonia, Vieillard, 1868, Sagot 347.
Moerei:—Java, from Sumatra, Wakker, 1896.
Moindiene:—New Caledonia, Vieillard, 1863, Sagot 347.
Moir's White:—Hawaii, Eckert, Bull. 17: 9, 1906.
Mojorah:—Assam, Barber, Studies 3.
Molle:—Argentine, from Brazil, Zerban, 1910. See Morado del País.

Momcha:—India, Clark & Hadi.
Monanion:—Mauritius, from New Caledonia (Lavignac), Horne, 1869.
Mona Seedling:—Jamaica, Rept. Sug. Sta. 2:57, 1908.
Monjet:—Java, Soltwedel, fig. 13. The plate represents a slender, dark-purple cane with no bloom but surface lines or cracks; nodes slightly constricted, growth ring yellowish, rather broad, rudimentary roots large in 3-4 broken rows, glaucous band well marked; buds broadly ovate, small, not exceeding the growth ring Quite distinct from Black Cheribon to which it is often referred. Gonsalves [written Teboe Mouget] = Black Cane.
Monte Alegre:—Brazil, Sao Paulo, Bull. 16:938, 1915.
Mont Blanc:—Jamaica, MacFadyen = Violet Cane [Black Cheribon] = Crystalina, Deerr. Barbados Rept. 1905-7:98.
Mont Eagle Seedling:—Jamaica, Rept. Sug. Sta. 2:64, 1908.
Moo Moo:—Queensland, from New Guinea, Maxwell, 1903-4.
Moomooboku:—Queensland, from New Guinea, 1895, Easterby.
Moore's Purple:—Queensland, from Mauritius, 1878, Easterby. N. S. Wales, planting permitted by Colonial Sug. Co., Int. Sug. Jour. 1:506, 1899. Resistant to Gum Disease, E. F. Smith. = Black Cheribon, Deerr.
Mootora:—Cent. India, Watts' Dict. 6(2):69.
Moracabo:—Madras, India, Watts' Dict. 6(2)·76. [See Maracabo.]
Morada:—Spanish America, = Black Cheribon, Deerr.
Morada del Brazil:—Argentine, from Brazil, Zerban, 1910. Very similar to Lousier de Mauricio, Kessaman, Roxa Oscura de Sao Simao and Lousier. [They probably all equal Cavengirie.]
Morada del País:—Argentine, from Brazil, Zerban, 1910. Much resembling this are the Listada Julien, Molle, and Fistula de Sao Samao. Probably all equal Louisiana Purple. [= Black-Cheribon.]
Morel Cane:—Louisiana, John Diamond, 1886. = Murillo, = Mexican Ribbon [Striped Cheribon].
Morris:—Demorara, Harrison & Jenman. Nearly identical with Meligeli.
Moueouete:—New Caledonia, Vieillard, 1863, Sagot 347.
Moujet:—Java. See Monjet.
Mouptora:—India, Watts' Dict. 6(2):70.
Mozambique:—Java, from Malacca, Wakker, 1896.
M. P.:—(As initials with numbers) Mauritius = Perromat Seedlings. Dept. Agr. Bull. 2:11, 1916. Barbados, Rept. 1915-17: 72.
Muggurwar:—Cent. India, Watts' Dict. 6(2):69.
Munggee:—India, Watts' Dict. 6(2):69. Also Mungia and Mungya.
Mungoo:—India, Papers—Sugar, 1822, Watts' Dict. 6(2):57. [See Mango.]
Mungo Beheea:—Java, from English India, Kobus, Med. 48, 1893.
Mungo Shahjahanpore:—Java, from English India, Kobus, Med. 48, 1893.
Muhk:—India. Watts' Dict. 6(2):70.

Muntok:—Java, from Banca, Deerr. Resistant to Sereh, E. F. Smith. Bact. 3: 77.
Muntok Zwart:—Java, Kobus, Med. 6. 1893.
Muritius Malagache:—Philippines, from Australia, Hines, Agr. Rev. 8: 157, 1915 [Mauritius].
Mutaira:—India, Watts' Dict. 6(2): 70.
Mutua:—India, Watts' Dict. 6(2): 69.
Naanal:—India, Barber, Studies 2, 3.
Naga:—Mauritius, from New Caledonia (Lavignac), Horne, 1869. Jamaica, from Mauritius, 1882, D. Morris. Louisiana, from Jamaica, Stubbs, Agr. Demorara, = Keening, Harrison & Jenman.
Naga B.:— = Crystalina, Deerr.
Nagamié:—Mauritius, from New Caledonia (Lavignac), Horne, 1869.
Nagapoury:—Jamaica, from Mauritius, 1882, D. Morris. = Naga? or Keening?, Bowery Bull. 4 (n. s.): 227 1897.
Nain:—Jamaica, from Mauritius, 1882, D. Morris. = Mani, Bowery, Bull. 4 (n. s.): 227, 1897. Java, from Malacca, Wakker, 1896.
Nainan:—Madras, India, from Mauritius, Watts' Dict. 6(2): 76.
Namala:—Madras, India, Benson, Int. Sug. Jour. 2: 469, 471, 1900.
Naman:—India, Barber, Studies 2.
Nanal:—Madras, India, Deerr. [See Naanal.]
Nargori:—India, Barnes, Taylor, Woodhouse.
Natal:—Mauritius, Boname, 1896, 1898–9.
Nave, or Mave:—Queensland, from New Guinea, 1895, Easterby.
Neengon:—New Caledonia, Vieillard, 1863, Sagot 345.
Negros:—Philippines, Agr. Rev. 6: 618, 1913.
Negros Purple:—Philippines, Agr. Rev. 6: 618, 1913. Argentine, from Philippines, Rev. Tuc. 9(1): 14, 1918.
Neligeli:—Demorara, Harrison Rept. 1894–5. [See Meligeli.]
Neula:—India, Watts' Dict. 6(2): 62.
Newar:—India, Papers—Sugar (1792), 1822, Watts' Dict. 6(2): 57.
New Caledonian Queen:—Mauritius, formerly known as Kavenger, Boname, Rept. 1895, 1898–9. [The name at least is new.]
New Guinea:—Argentine, from Philippines, Rev. Tuc. 9(1): 14, 1918.
N. G.:—(Initials with numbers) Queensland, represents canes imported from New Guinea under number about 1895.
N'ga-Brou:—New Caledonia, Breslau, 1884, Sagot 332.
N'ga-Cari:—New Caledonia, Breslau, 1884, Sagot 332.
N'gada:—New Caledonia, Breslau, 1884, Sagot 331.
N'gala:—New Caledonia, Vieillard, 1863, Sagot 347.
N'ga Mie:—New Caledonia, Breslau, 1884, Sagot 332.
N'ga Opa:—New Caledonia, Breslau, 1884, Sagot 332.
Nia do Quoin Mie:—New Caledonia, Breslau, 1884, Sagot 334.
Nia do Quoin Pa:—New Caledonia, Breslau, 1884, Sagot 334.
Nichols:—Louisiana, a light-striped bud sport, Stubbs. Queensland, from Louisiana, 1895, Easterby.
Niembla:—New Caledonia, Vieillard, 1863, Sagot 346.

Nieuw Guinea Geel:—Java, Kobus, Med. 6, 1893.
Nieuw Guinea Gestreipt:—Java, Kobus, Med. 6, 1893.
Nieuw Guinea Rood:—Java, Kobus, Med. 6, 1893.
Nieuw Guinea Zwart:—Java, Kobus, Med. 6, 1893.
Niliva:—Bombay, India, = Jowari White, Knight.
Nipa:—Java, from Sumatra, Wakker, 1896.
Nipa Telok Betong:—Java, Kobus, Med. 6, 1893.
Njamplong:—Mauritius, Horne, 1869. Java, Geerligs, West-Java, Med. 27.
Njamplong de Sourabaija:—Java, Krajenbrink, The Sugar Cane 2: 190, 1870.
Nora Tava:—Demorara, = Keni Keni, Harrison & Jenman.
Norman:—Jamaica, Bot. Bull. 2. Demorara, = Mani, Harrison & Jenman, Louisiana, from Jamaica, Stubbs, Agee.
Numa:— = Black Cheribon, Deerr.
Nyamplong:—Mauritius, Horne, 1869. [See Njamplong.]
Oedang:—Java, from Amboina, & Sumatra, Wakker, 1896; Soltwedel, fig. 21. The plate represents a medium stout green and purple striped cane with barrel-shaped internodes and strongly constricted nodes, growth ring broad, yellowish or brownish; bud ovate, margin uniform, not shuldered.
Ohia:—Louisiana, from Hawaii, Stubbs, Agee.
Oiboku:—Queensland, from New Guinea, Maxwell, Rept. 1903–4
Oiva:—Queensland, from New Guinea, 1895, Maxwell, Easterby. N. S. Wales, planting permitted by Colonial Sug. Co., Int. Sug. Jour 1·506, 1899.
Oliana:—Hawaii, Deerr, Roch.
Ombonoutou:—New Caledonia, Breslau, 1884, Sagot 337.
Onata:—Mauritius, from New Caledonia (Lavignac), Horne, 1869.
Onboonontoua:—Mauritius, from New Caledonia (Lavignac), Horne, 1869.
Ook:—India, Papers—Sugar Ap. 1: 142, 1822.
Oraya:—Queensland, from New Guinea, 1895, Easterby.
Otaheite:—Louisiana & Florida, Silliman, 1833. Louisiana, Fleischman, with colored plate, 1848. Jamaica, Bligh, 1793, Deerr. = Bamboo II, Bourbon, Cayenne, China, Colony, Cuban, Keni Keni, Lahaina, Lousier, Portii, Singapore; possibly more than one variety is included. [See Oudinot.] In Jamaica Bot. Bull. 2. = Crystalina, Deerr. In Reunion, = Black Cheribon, Deerr. In Queensland, = Chinese, Davidson.
Otaheite Ribbon:—Wray, = Striped Tanna, Deerr.
Otaheite with Purple Bands:—Evans, The Sugar Planter's Manual, p. 37. [Probably = Striped Cheribon.]
Otamite:—Mauritius, Boname, 1895, badly attacked Gum Disease, 1896, 1898–9. Queensland, Easterby [Clearly = Cavengirie. The note on Gum Disease by Boname indicates that his cane is different, for Cavengirie resists Gum Disease.] See also Outamite.
Otang:—Java, from Sumatra, Wakker, 1896.

Otomato:—Philippines, from Australia, Hines, Agr. Rev. 8:157, 1915. [The description resembles Cavengirie; probably a misprint for Otamite.]
Ouale:—New Caledonia, Vieillard, 1863, Sagot 347.
Ouane:—New Caledonia, Vieillard, 1863, Sagot 347.
Ouata:—Mauritius, from New Caledonia (Lavignac), Horne, 1869.
Ouatamite:—New Caledonia, Breslau, 1884, Sagot 343. [Probably the original from of Otamite. It is described as a wine-red cane with black bands, again indicating Cavangire].
Oubounoutoo:—New Caledonia, Caldwell, The Sugar Cane 3:208, 1871.
Oudinot:—Hawaii, Deerr & Eckert, Bull. 26:8, 1908. = Cuban, = Keni Keni (a native name meaning numerous). One of the canes brought to Hawaii from Otaheite in 1854 by Capt. Pardon Edwards, the other being Lahaina.
Oue Merou:—New Caledonia, Breslau, 1884, Sagot 336.
Oue Mie:—New Caledonia, Breslau, 1884, Sagot 336.
Ouen Mangia:—New Caledonia, Vieillard, 1863, Sagot 348.
Ouenebail:—New Caledonia, Vieillard, 1863, Sagot 347.
Ouenoupoudendate:—New Caledonia, Vieillard, 1863, Sagot 346.
Ouentouta:—New Caledonia, Breslau, 1884, Sagot 342.
Oucpa:—Queensland, from So. Sea Islands, 1874, Easterby.
Ouerou:—New Caledonia, Vieillard, 1863, Sagot 346.
Oura:—Society Islands, Cruzent, 1860.
Ouremendo:—New Caledonia, Breslau, 1884, Sagot 342.
Outamite:—Queensland, from So. Sea Islands, 1874, Easterby. [See Otamite & Ouatamite.]
Pachrangi:—India, Watts' Dict. 6(2):67.
Padang:—Java, Kobus, Med. 6, 1893.
Paiambou:—New Caledonia, Vieillard, 1863, Sagot 346.
Paieme:—New Caledonia, Vieillard, 1863, Sagot 348.
Paiowara:—India, Bengal (Chapman), Watts' Dict. 6(2):60.
Palani:—Hawaii, Roch, Bull. 2, 1913.
Palania:—Hawaii, Deerr.
Palembang:—Java, Kobus, Med. 6, 1893.
Palfrey Cane:—Louisiana, John Diamond, 1888 = Crystalina.
Palmyra:—Queensland, = Goi Goi, = New Guinea 42, Easterby.
Palo Rojo:—Porto Rico, Stahl, López Tuero = Bois Rouge.
Palo Rojo Claro:—Porto Rico, Stahl, = Bois Rouge Blonde.
Pamplemousses:—(With numbers) a series of seedlings grown in Mauritius, a number have been brought to Queensland.
Panache:—Louisiana, from Jamaica, Stubbs, Agee. = Crystalina, Deerr.
Pandaan Poetih:—Java, Kobus, Med. 6, 1893.
Pandia:—India, Watts' Dict. 6(2):62.
Pangka:—Java, Ledeboer, Med. 4:452, 1917.
Pansahi:—India, Watts' Dict. 6(2):60; Barber, Studies 2; Taylor, Woodhouse (as Panshahi).
Pansari:—India, Clark & Hadi.

Pa-o-le:—Demorara, = Altamattii, Purple Mauritius, Cavengirie, Giant Claret, Harrison & Jenman. [See Po-a-ole.]
Papaa:—Hawaii, Deerr, Roch. Louisiana, from Hawaii, = Ohia, = Honuaula, Stubbs, Agee.
Papaliva:—Queensland, from Java, 1878, Easterby.
Pappoa:—Louisiana, from Cuba, Agee, Bull. 127:16, 1911.
Papua:—Java, from Java, Wakker, 1896.
Paramaribo:—Java, Kobus, Med. 6, 1893.
Pariah:—Mauritius (Duval). Queensland, = Meera, Davidson.
Parrah:—Queensland, from Mauritius, 1878, Easterby.
Passaeraewan:—Mauritius, from Java, Horne, 1869.
Passaroewan:—Queensland, from Java, 1874, Easterby.
Passar:—Mauritius, from Java, Horne, 1869. Queensland, from Java, 1874, Easterby.
Passin:—Java, from Sumatra, Wakker, 1896.
Patarki Mango:—India, Clark & Hardi, Barnes.
Pattapatti:—Mysore, India, Ag. Calendar, 1915.
Patu:—Tahiti, Dr. Bennett, The Sugar Cane 6:593, 1874
Paunda:—India, Watts' Dict. 6(2):60. A class name proposed by Hadi for the stout introduced canes, Ukh and Ganna, for the slender and intermediate canes, Deerr.
Paungdi:—India, Papers—Sugar, 3d. Ap. 35, 1822.
Paunri:—India, Taylor, Woodhouse.
Panole:—Hawaii, = Cavengirie, Deerr. [See Po-a-ole.]
Pena (Penang):—Bahía, Brazil, The Sugar Cane 22:483, 1890.
Penabar:—Java, from Sumatra, Wakker, 1896.
Penang:—Mauritius, from Java, 1850. Dept. Ag. Bull. 2:11, 1916. Queensland, from Mauritius, 1878, Easterby. = Salangore, Davidson, Deerr.
Perromat:—(With numbers) A series of seedlings produced in Mauritius. Some introduced in Queensland.
Petite Senneville:—Mauritius, Agr. Bull. 2:5, 7, 1916. = Improved M. P. 133. Queensland from Mauritius, 1901, Easterby.
Platnaiya:—India, Watts' Dict. 6(2)·62.
Philippine Blanche:—Mauritius, Boname, 1898–9.
Philippine Rouge:—Mauritius, Boname, 1898–9.
Phusburi:—Bombay, India, = Fudburi, Knight
P. I.:—(Initials with numbers) Seedlings made in the Philippines by C. W. Hines, Agr. Rev. 10:32, 1917.
Piaverae.—Pacific Islands, Deerr.
Piavere:—Society Islands, Cruzent, 1860. = *Sac obscurum Trin.*
Pidiak:—New Caledonia, Vieillard, 1863, Sagot 348.
Pilimai:—Hawaii, Eckert, Bull. 17:9, 1906.
Pinang:—Porto Rico, Stahl; López Tuero, Reunion. Colson. = Salangore, Deerr. [See Penang.] Applied to a different cane in Porto Rico.
Pine:—Jamaica, Bot. Bull. 2.
Pink Cane:—Queensland, from New Caledonia (Muir), Davidson, 1880.

Pink Ribbon:—Queensland, from New Caledonia (Muir), Davidson, 1880, Easterby.

Pitu:—Brazil, Pernambuco, Bull. 3. = Roxa, listado. Gorkum, Weller, The Sugar Cane 25: 187, 1893. Demorara, Jour. Brit. Guian. 10: 66, 1917.

P. K.:—(Initials with numbers) Java, Harreveld, Med. 4: 1654, 1919.

Ploucaoua:—New Caledonia, Breslau, 1884, Sagot 335.

Po-a-ole:—Jamaica, from Mauritius, 1882, D. Morris. Louisiana, from Jamaica, Agee. Java, from Malacca, Wakker, 1896. Demorara, = Jamaica, = Barbados, = Purple Mauritius, Harrison & Jenman. = Cheribon, Deerr. [See Pa-o-le.]

Pobone:—New Caledonia, Vieillard 1863, Sagot 346.

Po d'ouro:—Campos, Brazil, Gorkum. [= Poudre de Oro?.]

Poerbolinggo:—Java, from Java, Wakker, 1896.

Poetih:—Java, from Java, Timor, Amboina, Menado, and Sumatra, Wakker, 1896.

Poetii:—Brisbane Bot. Gar., from Java. The Sugar Cane 2: 104, 1870. [See Portii.]

Poetri:—Java, from Sumatra, Wakker, 1896.

Poilote:—New Caledonia, Vieillard, 1863, Sagot 345.

P. O. J.:—(Initials after numbers) The seedlings grown at Proefstation Oost-Java, the East-Java Field Station at Pasoeroean by Kobus. Many of them are crosses of the North Indian Chunnee on the Black Cheribon. These crosses are resistant to Sereh and to Root Disease and tolerant of Mosaic.

Ponda:—India, Watts' Dict. 6(2): 69.

Ponna:—Also written Pona and Puna. India, grown all over the Punjab for eating; seldom used for sugar. The Sugar Cane 15, 644, 1883. Watts' Dict. 6(2): 66, 67. [See Pundia.]

Pooree:—India, Papers—Sugar (1792), 1822. West Indian planters are quoted as saying it is the same as the cane grown there. [A colored plate might pass for Creole but it is badly drawn.] [See Puri.]

Poori:—India, Roxburgh, under *Sac. officinarum.*

Poovan:—India, Barber, Studies 2.

Poraya:—India, Taylor; Woodhouse.

Portier:—Louisiana, = Lahina = Keni Keni. Considered distinct from Otaheite, Stubbs, from the Marquesas, Agee. [See Portii, Poetii & Poetih.]

Portii:—Mauritius (from Java). Horne, 1869; a chalky gray cane. Hawaii, Durr & Eckert, = Otaheite, Deerr.

Port Mackay:—Mauritius, from Queensland, 1869, Dept. Agr. Bull. 2: 5, 1916. Boname, 1895, 1898–9. Reunion, a red cane (Delteil), Sagot 330, Colson. Java, from Hawaii, Wakker, 1896. Brazil, locally known as Louzier, Purple Cane, Black Cane, &c, introduced to Pernambuco twenty years ago to combat Gum Disease, Int. Sug. Jour. 1: 379, 1899; Sao Paulo Sawyer; Gorkum. = Cavengirie Deerr. Java, Kruger 145, a yellowish green cane with brown dots. Argentine, from Brazil, Zerban, 1910, a green cane [evidently two canes are mixed under this name.]

Port Mackay Noir:—Mauritius Deerr, a black sport from Cavengirie, Boname, 1898–9.
Poteii:—Queensland, from Java, 1874 Easterby. [See Portii &c.]
Poudre Blanche:—Brazil, Sao Paulo, Sayer, 1908. Argentine, from Brazil, Zerban, 1910.
Poudre d'Oro:—Brazil, Sao Paulo, Sawyer, 1908. Natal, The Sugar Cane 9: 322, 1877. Argentine, from Brazil, Zerban, 1910.
Poudre d'Or Rayée:—Mauritius and Reunion, from New Caledonia (Delteil), Sagot 328. Guadeloupe, Boname, 1888.
Pounemate:—New Caledonia, Vieillard, 1863, Sagot 345.
P. R.:—(Initials with numbers) Seedlings grown in Porto Rico. Nos. 1–200 were produced at the Federal Experiment Station at Mayagüez. Numbers above 200 at the Insular Station at Río Piedras.
Prata:—Barbados, Rept. 1908–10: 55, 1911.
Preta:—Demorara, Jour. Brit. Guian 10: 66, 1917.
Pring:—Java, = White Cane, Kajenbrink, The Sugar Cane 2: 192, 1870.
Providence:—(With numbers) Demorara, Jour. Brit. Guian. 11: 156, 1918.
Puaolle:—Mauritius, from Sandwich Isl., Horne, 1869. Hawaii, Roch. Bull. 2, 1913.
Pulvo de Oro:—Bahía, Brazil, The Sugar Cane 22: 483, 1890. [See Poudre d'Or.]
Pundi:—India, Taylor.
Pundia:—Bombay, India, Watts' Dict. 6(2), 74. A large white cane, supposed to be two varieties, one indigenes and one imported from Mauritius; probably both are importations. [= Otaheite?.] Knight. Bull. 61, 1914, = Gubbi Rasadli. [See Punna &c.]
Pundyabas:—Bombay, India, Watts' Dict. 6(2): 73.
Pungdi:—India, Watts' Dict. 6(2): 57.
Punri:—India, Bengal (Chapman), Watts' Dict. 6(2): 60.
Punsaree:—Benares, India, Papers—Sugar, 1822.
Pupuha:—Louisiana, from Hawaii, Stubbs, Agee.
Purhea:—India, Watts' Dict. 6(2): 70.
Puri:—India, Watts' Dict. 6(2): 57, Bengal, illustrated by East India Co., in 1792. A soft, yellow cane. [See Pooree]; Sabour, Taylor; Woodhouse. Java, Kobus, from English India, Med. 48, 1893. Wilbrink & Ledeboer, Med. 6: 86, 1911; Van Deventer, Handb. 5: 142, 1915.
Purisave:—Benares, India, Watts' Dict. 6(2): 57.
Purple Bamboo:— = Louisiana Purple, = Black Cheribon, Deerr.
Purple Cane:—Brazil = Port Mackay [=Cavengirie.]
Purple Cheribon:—Mauritius, = Cane Beloujuet [Black Cheribon].
Purple Elephant:—Louisiana, from Cochin China, Stubbs; from Hawaii, Agee.
Purple Jamaique:—Mauritius, Boname, 1896, 1898–9. [= Black Cheribon.]
Purple Mauritius:— = Black Cheribon, Deerr.
Purple Native:—Philippines, Wakker, = Negros Purple.

Purple Otaheite:—Evans, The Sugar Planter's Manual 37, 1847. [= Black Cheribon.]

Purple St. Louis:—N. S. Wales, Int. Sug. Jour. 1: 506, 1899, Colonial Sug. Co. permits planting certain districts.

Purple Transparent: = Black Cheribon, Deerr, Harrison & Jenman.

Purple Violet:—Wray, = Black Cheribon, Deerr.

Pusin:—Java, from Bovenlanden, Wakker, 1896.

Putih:—Kruger 145. [See Poetih.]

Putli Khajer:—India, Barber, Studies 2, 3.

Putta Putti:—India, Papers—Sugar 3d Ap. 12, 1822; Watts' Dict. 6(2): 76.

P. W. D.:—(As initials with numbers) Java, Harreveld, Med. 12: 1708, 1918.

Q.:—(As initials with numbers) Seedlings grown in Queensland by the Aclimatization Soc. 1900 to 1907, Easterby.

Queensland:—Jamaica, Bot. Bull. 2. Bull. 4(n. s.): 227, 1897, Bowery. = Queensland Creole?

Queensland Cane:—Trinidad, = Badilla.

Queensland Creole:—Barbados, Rept. 1905–7: 25, 1908. Demorara, = Black Cheribon, Harrison & Jenman, Deerr.

Queensland White Bamboo:—Barbados, Rept. 1905–7: 34, 1908.

R.:—(As initial with numbers) indicates Seedling produced at **Rarawai, Fiji.**

Radjek:—Java, from Java, Wakker, 1896.

Raileve:—New Caledonia, Breslau, 1884. Sagot, 339.

Raishmi:—Cent. India, Watts' Dict. 6(2): 69.

Rajado:—Brazil, Sao Paulo, Sawyer, 1908 [Rayada?].

Rakhoti:—Cent. India, Watts' Dict. 6(2): 69.

Raksi:—India, United Prov. Barber, Studies 3.

Raksida:—India, N. W. Prov. Watts' Dict. 6(2): 62.

Ramrasdali:—India, Bombay, = Kasbirya, Knight. Watts' Dict. 6(2): 73.

Ramrasul:—India, Bombay, Watts' Dict. 6(2): 74.

Ramui:—India, United Prov. Barber, Studies 3.

Rangi-Kali:—India, Assam (Stack), Watts' Dict. 6(2): 62.

Rapoe:—Variously spelled, Rapoehe, Rapooh, Rappoe, &c. Usually taken to = Crystalina, but in **Mauritius and Queensland it is a striped cane, probably Striped Cheribon.** Soltwedel, **fig. 11, represents a medium diameter, ash-green** cane with **slight flush and evidently a heavy bloom**; nodes slightly constricted; buds **broadly oval, not shouldered.** It would pass for Crystalina except for the buds, but as usual these are evidently carelessly **drawn.**

Rapooh Kiang:—**Java, Soltwedel, fig. 14,** which represents a **medium stout purple cane apparently with heavy bloom**; nodes slightly **constricted, growth ring yellow, very broad and conspicuous; buds broadly ovate but with an acuminate point.**

Rappoe Koening:—**Mauritius, from Java, Horne, 1869. Hawaii, Deerr & Eckert.**

Rappoe Maeda:—Mauritius, from Java, Horne, 1869. Hawaii, Deerr & Eckert.

Rappoe Posai:—Queensland, from Java, 1878, Easterby.

Rasdale:—Bombay, India, Knight.

Rasal:—India, Bombay, Watts' Dict. 6(2):73.

Rat:—Mauritius, Boname, 1898–9.

Rat-Gros-Ventre:—Reunion, Colson, 1905.

Rattan:—Queensland, from Java, 1874, Easterby.

Raungda:—India, Papers—Sugar, 3d Ap. 35, 1822. Watts' Dict. 6(2):57.

Ravannais:—Argentine, from Brazil, Zerban, 1910. = Rayada del País, Rev. Tuc. 9, 132.

Raweh:—Java, Med. Oost-Java, 7:4.

Rayada:—All Spanish American countries, = Striped Cheribon.

Rayada del País:—Argentine, from Brazil, Zerban, 1910. = Ravannais, = Yunscao, = Cayana Rosa, = Riscada de Sta. Bárbara, = Red Ribbon [Striped Cheribon].

Red Assam:—Bengal, India, Wray. N. S. Wales, introduced from India, The Sugar Cane 14, 50, 1882.

Red Baruma:—Queensland, from New Guinea as No. 47, Easterby.

Red Bombay:—India, Bengal (Chapman), Watts' Dict. 6(2):60; Taylor; Woodhouse. = Bombay.

Red Borneo:—Kruger 141, = Tebu Merah, Borneo, = Juts Lumarrohr.

Red Cane:—Georgia, Florida, = Louisiana Purple, Yoder, U. S. Dept. Agr. Bull. 486.

Red Cane of Batavia:—Java, Krajenbrink, The Sugar Cane 2:192, 1870. [Probably = Black Cheribon though other red canes may have been included.]

Red Cuttarah:—Mauritius, Horne, 1869.

Red Java:—Sabour, India, Taylor; Woodhouse. Probably identical with Red Tanna [Black Tanna].

Red Joeno:—Java, from Java, Wakker, 1896; Kobus, Med. 6, 1893.

Red Lousier:—Mauritius, Agr. Dept Bull. 2:11, 1916. A red sport form Lousier [Otaheite].

Red Manila:—Java, Deerr; nodes swollen.

Red Mappo:—Queensland, from Mauritius, 1878. Easterby. Java, from Australia, Wakker, 1896.

Red Mauritius:—India, Barber, Studies 2; Knight; Taylor; Woodhouse.

Red Punda:—India, Bengal (Chapman), from Mauritius, Watts' Dict. 6(2):60.

Red Ribbon:—The numerous citations usually = Striped Cheribon. Occasionally Striped Tanna is probably confused with this. The Red Ribbon of the Brisbane Bot. Gar. from New Caledonia was neither of these kinds if Hill's description of "leaves with bristly hairs at base" is correctly understood.

Red Ribbon of Batavia:—Mauritius, Bouton. [= Striped Tanna?].

Red Rose Ribbon:—Jamaica, Bull. 4:227, 1897. = Red Ribbon.

Red Striped Lousier:—Mauritius, Ag. Dept. Bull. 2: 11, 1916, originated as a sport from Lousier. [= Horne.]
Red Tanna:—India, Taylor, Woodhouse, = Red Java [Black Tanna].
Regnard:—Mauritius, Boname, 1895.
Reina:—Bahía, Brazil, The Sugar Cane 22: 483, 1890. [See Reine.]
Reina de Caledonia:—Porto Rico, Stahl; López Tuero.
Reine:—Mauritius, Boname, 1896, 1898–9. Argentine, from Brazil, Zerban, 1910.
Reonda:—India, Papers—Sugar, 1822, Watts' Dict. 6(2): 61.
Reongra:—India, Watts' Dict. 6(2): 60.
Reonra:—India, Watts' Dict. 6(2): 62.
Reora of Benareo:—North India, Barnes; Clark & Hadi (as Reori).
Reora of Gorakhpur:—India, Clark & Hadi.
Restali:—India, Papers—Sugar, Ap. 2: 12, 1822. Madras, = Striped Cheribon?, Deerr.
Retrench:—(With numbers) Trinidad, = Hill's Seedling.
Rheora:—India, Taylor; Woodhouse. [See Reora.]
Rhi:—Mauritius, from New Caledonia (Lavignac), Horne, 1869. Queensland, from So. Sea Islands. 1874, Easterby.
Riat Tengang:—Java, from Borneo, Wakker, 1896.
Ribbon:—As usually used = Striped Cheribon.
Riman:—Java, from Sumatra, Wakker, 1896.
Rimon:—Java, from Bovenlanden, Wakker, 1896.
Rinaio:—Mauritius, from New Caledonia (Lavignac), Horne, 1869.
Riscada:—Brazil, Sao Paulo, Bot. Ag. 16: 731, 1915. Argentine, from Brazil, Zerban, 1910.
Riscada de Sta. Bárbara:—Argentine, from Brazil, Zerban, 1910. [See Rayada del País.]
River from St. Andrews:—Barbados, Rept. 1907–9: 33, 1910.
River from Sta. Lucía:—Barbados, Rept. 1907–9: 33, 1910.
Rocha:—So. Africa, from Formosa, Choles.
Rock Hall:—Barbados; West Ind. Bull. 2: 26, 1901. St. Kits, West Ind. Bull. 8: 36, 1907.
Roixa:—Brazil, = Listrado de Amarillo, = Violacea, Moreira, 1876. [See Roxa.]
Roixa de Folha Roixa:—Brazil, Moreira, 1876.
Roja de Martinica:—Brazil, Weller, The Sugar Cane 25: 1871, 1893.
Rood:—Java, from Dutch New Guinea, Wakker, 1896.
Rood Ceram:—Java, Wilbrink & Ledeboer, Med. 6: 86, 1911, Van Harreveld.
Rood Duitsch Nieuw Guinea:—Java, Jeswit. Med. Deel VI. (13); 400, 1916, with full desc.
Rood Keong:—Java, Geerligs, Med. West-Java, 27.
Rood Manila:—Java, from Philippines, 1886, Van Derventer, Handb. 5; 149, 1915.
Rood Raphoh:—Java, from Bagalen, Wakker, 1896.
Rood Shamshara:—Java, from Bombay, Kobus, Med. 48, 1893.
Rosa:—Brazil, Bahía, The Sugar Cane 22: 483, 1890. Sao Paulo, Bot. Ag. 16: 727, 1915. Argentine, from Brazil, Zerban, 1910. Barbados, Rept. 1908–10: 55, 1911. Demorara, Jour. Brit. Guian. 10: 66, 1917.

Rosa de Sao Simao:—Argentine, from Brazil, Zerban, 1910.
Rosa Morada:—Porto Rico, from New Caledonia, Stahl; López Tuero.
Rose Bamboo:—Hawaii, Queensland and most other citations = Crystalina. In Porto Rico Yellow Caledonia was first distributed as Rose Bamboo.
Rose Diard:—Queensland, from Mauritius, Davidson, 1880. The Diard canes are supposed to = Cheribon canes, but Davidson's description gives "canes itch strong". Evidently not a Cheribon Cane.
Rosita.—Porto Rico, a popular name for Cavengirie.
Rotan:—Java, from Amboina, Wakker. 1896. Soltwedel, fig. 18, represents a medium slender, green and yellow striped cane; internodes long and slightly enlarged below, furrow conspicuous; nodes constructed above the scar; growth ring broad of two or three colored bands; buds narrowly ovate.
Rotan Poetih:—Java, from Amboina, Wakker, 1896.
Rotten Idjo:—Java, Van Derventer, Handb. 5:151, 1915.
Roxa:—Brazil, Sao Paulo, Sawyer, 1908. Argentine, from Brazil, Zerban, 1910. [See Roixa.]
Roxa de Sta. Bárbara:—Argentine, from Brazil, Zerban, 1910.
Roxa de Sao Simao:—Argentine, from Brazil, Zerban, 1910. [See Morada del País.]
Roxa Louzier:—Brazil, from Mauritius, Deerr.
Roxa Oscura de Sao Simao:—Argentine, from Brazil, Zerban, 1910. = Morado del Brazil, = Cavengerie.
Roxina:—Brazil. = Bronzeada, Deerr.
R. P.:—(With numbers) Demorara, Jour. Brit. Guian. 11:157, 1918.
Ruckkree:—Java, from English India, Kobus, Med. 48, 1893. Wilbrink & Ledeboer, Med. 6:86, 1911, Van Derventer, Handb. 5: 141, 1915.
Rurutu:—Pacific Islands, Deerr. Society Islands, Cruzent, 1860. Simmons Tropical Agriculture, 1877.
Russell:—Demorara, Harrison & Jenman.
Rutu:—Tahití, Dr. Bennett, The Sugar Cane 6:593, 1874. [See Rurutu.]
Saccharum:—The botanical generic name for sugar cane.
Sacuri:—Jamaica, from Mauritius, 1822, D. Morris. Demorara, Harrison & Jenman. = Lakona. Louisiana, from Jamaica, Stubbs. Java, from Malacca, Wakker, 1896. [All references trace to Jamaica where the name seems to have originated.] [See Securi and Samuri.]
Safaid:—India, Watts' Dict. 6(2):69.
Sagao:—Philippines, Walker, Sugar Inds. Isl. of Negros 77.
Sagari:—India, Watts' Dict 6(2):72.
Saharanpuri:—India, Watts' Dict. 6(2):67. = Saharri, = Dhaulu.
Saigon:—Queensland, from Singapore, 1880, Easterby.
Salah:—Java, from Malacca, Wakker, 1896.
Salangore:—Straits Settlements, Wray. [A well-marked variety widely discussed in the literature.] = Tibboo Biltong Berabou, Tiboo Capor, Tinang (or Penang), White Mauritius (in Demo-

rara), Green Transparent (Demorara), Canne Rocha, Chinese Cane (Bourbon), Chalk Cane, Deerr.

Salangor Blanca:—Porto Rico, Stahl. = Belugue Blanco.

Salangor Palmeira:—Bahía, Brazil, The Sugar Cane 22: 483, 1890.

Salangor Rayada:—Porto Rico, Stahl. = Belugue Rayada. [=Striped Cheribon?.]

Salangor Roja:—Porto Rico, Stahl. = Belugue Rojo. Much like Cavengirie but lacks the stripes.

Samoan:—Java, from Malacca, Wakker, 1896.

Samsara:—Bengal, India, Ag. Inst. Pusa, Bull. 83, 27, 1919. Demorara, West Ind. Bull. 5, 336, 1905. [See Somsarrah,]

Samuri:—Jamaica, from Mauritius, 1882, D. Morris. The favorite kind in Fiji, The Sugar Cane 17: 153, 1885. Demorara, Harrison & Jenman. Java, from Malacca, Wakker, 1896. [See Sacuri.]

Sanacki:—North India, Barnes.

Sandal:—Mauritius, Boname, 1895, 1898–9.

Sandwich:—Java, Geerligs, Med. West-Java, 27.

Sannabile:—Bombay, India. = Devagadi, Knight. [See Sunnabile.]

San Pello:—Brazil, = Manteiga, Deerr. [See Sem Pello.]

San Salvador:— = Striped Cheribon, Deerr.

Sarangola:—Porto Rico. A local name sometimes applied to Crystalina.

Sararu:—India, Watts' Dict. 6(2): 67.

Sarautia:—India, N. W. Prov. Watts' Dict. 6(2): 62.

Sarauti:— India, Clark & Hadi.

Sarawati:—India, Bengal (Chapman), Watts' Dict. 6(2): 60.

Saretha:— India, a group name, Barber, Studies 3, also 2.

Saroti:—India, Watts' Dict. 6(2): 60.

Sarotiyo.—India, Watts' Dict. 6(2): 60.

Saska:—Java, from Sumatra, Wakker, 1896.

Sawoer:—Java, from Java, Wakker, 1896. = Idjo Hong-kong, Kobus, Med. 6, 1893. Soltwedel, fig. 30. This represents a slender greenish cane with bloom much blackened by sooty mould; constricted at growth ring. It resembles the North Indian canes.

S. C.:—(Initials with numbers) Pernambuco Brazil, = Cannas de Sao Caetano, Bull. 3. Virgin Islands = Seedlings grown at the St. Croix Exp. Sta. by Longfield Smith, Rept. 1: 14–18, 1913. Barbados, Rept. 1816–18: 69. These numbers probably refer to St. Croix seedlings. Brazil, Gorkum also uses the initials S. C. A. Sc. B., and S. C. H. but without explanations.

Scard:—Demorara, Harrison & Jenman, also West Ind. Bull. 1(4): 381, 1900.

Scavangerie:—Guadeloupe, Boname, 1888. Mauritius & Reunion from New Caledonia, Sagot 328. = Cavengirie, Deerr.

Schimate:—New Caledonia, Vieillard, 1863, Sagot 346.

Sealey's Seedling:—Barbados, = Blackman's Seedling, Bovell West Ind. Bull. 2: 26, 1901. Trinidad, Bull. 73, 1919. Porto Rico, various publications.

Seche:—Mauritius, Boname, 1895. [See Seete?.]
Securi:—Queensland, from Louisiana, 1895, Easterby. [See Saouri.]
Seema:—Louisiana, from British India, Agee.
Seete:—Jamaica, from Mauritius, 1882, D. Morris. Demorara, Harrison & Jenman. = Striped Cheribon, Deerr.
Selabaloes:—Java, Kobus, Med. 6, 1893.
Selangore:—Jamaica, Demorara. [See Salangore.]
Selasih:—Java, from Sumatra, Wakker, 1896.
Sem Pello:—Brazil, Sao Paulo, Bull. 16: 942, 1915. Also Gorkum. [See San Pello.]
Senkoehoen:—Java, from Borneo, Wakker, 1896.
Sepadeh:—Java, from Sumatra, Arch. 1 Ap. 1892.
Sepang:—Java, from Sumatra, Wakker, 1896.
Sererat:—Queensland, from Java, 1878, Easterby. [See Soerat.]
Settlers:—Mauritius, Boname, 1896 (by misprint Setters).
Shakarchina:—Queensland, from Mauritius, 1902, Maxwell, Easterby. India, Watts' Dict. 6(2): 60.
Shakar Chinya:—India, Taylor; Woodhouse.
Shakar Chynia:—India, Barber, Studies 2.
Shamshara:—India, Taylor; Woodhouse. [See Rood and Geel Shamshara, Java.]
Sharang:—India, Bengal (Chapman), Watts' Dict. 6(2): 60.
Shoo:—New Caledonia, Breslau, 1884, Sagot 331.
Shukurchina:—India, Papers—Sugar, 3d. Ap. 35, 1822.
Siah:—India, Watts' Dict. 6(2): 69.
Siepa:—New Caledonia, Breslau, 1884. Sagot 333.
Sigei:—Java, from Bovenlanden, Wakker, 1896.
Simi:—India, Int. Sug. Jour. 2: 469, 1900.
Simpson:—Georgia, Florida, = Green Ribbon, Yoder, U. S. Dept. Agr. Bull. 486: 7, 1917.
Singapore:—India, Watts' Dict. 6(2): 49. [A mixture of varieties.] Java, from Australia, Wakker, 1896. Demorara, Harrison & Jenman. = Otaheite, Deerr.
Sipadeh:—Java, from Sumatra, Wakker, 1896.
Sirah:—Java, from Sumatra, Wakker, 1896.
Sisieq:—Java, from Sumatra, Wakker, 1896.
Sisie Koening:—Java, from Sumatra, Wakker, 1896.
Sisie Merah:—Java, from Sumatra, Wakker, 1896.
Small Ribbon:—Queensland, Davidson, 1880. [= Striped Cheribon.]
Small Yellow:—Queensland, Davidson, 1880, Easterby.
Socrat:—Queensland, from Java, 1874, Easterby [a misprint for Soerat].
Soerat:—A malay word meaning striped, applied to any striped cane, when used alone usually = Striped Cheribon but sometimes Striped Tanna.
Soerat Balie:—Java, from Java, Wakker, 1896. Kobus, Med. 6, 1893.
Soerat Banka:—Java, Kobus, Med. 6, 1893.
Soerat Bantang:—Java, Wakker, 1896. Soltwedel, fig. 17. Represents a stout, short-jointed cane with light and dark purple stri-

pes; nodes oblique, strongly constructed, rudimentary roots large, in 2–3 rows; buds thick, suborbicular but apiculate. It resembles Striped Tanna.

Soerat Buding:—Java, from Java, Wakker, 1896.

Soerat Gempolkerep:—Java, Soltwedel, fig. 22, represents a medium slender green and brown-red striped cane with heavy bloom; internodes cylindrical, slightly constricted at growth ring; buds small, suborbicular.

Soerat Hongkong:—Java, Oost-Java, Med. 9, 19.

Soerat Idjoe:—Java, from Batjan, and New Guinea, Wakker, 1896.

Soerat Item:—Java, from Borneo and Fiji, Wakker, 1896.

Soerat Koening:—Java, from Fiji, Wakker, 1896.

Soerat Mangli:—Java, from Java, Wakker, 1896. Soltwedel, fig. 23. Represents a rather stout green and red-brown striped cane; nodes conspicuously swollen; buds suborbicular, with a conspicuous, apical tuft of stiff barbs.

Soerat Mauritius:—Java, Soltwedel, fig. 24. Represents a medium slender cane with narrow red and brown stripes; internodes long and somewhat curved, enlarged below; buds rather large, triangular-ovate. A very peculiar appearing cane. Mauritius = Branchu Rayée, Deerr.

Soerat Merah:—Java, from Hawaii, Wakker, 1896.

Soerat Njampl·—Java, from Java, Wakker, 1896

Soerat Njamplong:—Java, Soltwedel, fig. 20. Represents a medium diameter, green and purple or yellow and purple striped cane internodes cylindrical or the nodes slightly constricted; buds broad, triangular with shouldered margin. The shape of the bud makes it quite clearly = Striped Cheribon.

Soerat Redjo:—Java, from Java, Wakker 1896. Geerligs, Med. West Java, 27.

Soerat Telok Betong:—Java, Med. Oost-Java 47: 58.

Soerat Tjeribon:—Java, Kobus, Med. 6, 1893. [= Striped Cheribon.]

Solangor·—Brazil, = Listrado de Roixa, Moreiro, 1876. [See Salangore.]

Somsarrah:—Mauritius, from India, Horne, 1869. [See Samsara.]

Sonabile:—India, Agr. Inst. Pusa, Bull. 83: 33, 1919. [See Sannabile and Sunnabile.]

Sonabochi:—North India, Barnes.

Songada Rati·—Bombay, India, Knight.

Soniat·—Louisiana, a white bud sport, Stubbs.

Spotted Mappoo:—Queensland, from Mauritius, 1878, Easterby.

Sthiabangui·—New Caledonia, Vieillard, 1863, Sagot 346.

Striped Ambos Camarines:—Philippines, = Striped Leyte.

Striped Bamboo.—Mauritius, = Striped Cheribon, Deerr.

Striped Bansa:—India, Taylor; Woodhouse.

Striped Bourbon·—Queensland, from Singapore, Davidson, 1880. Easterby. [= Horne.]

Striped Cheribon: = Rayada of Spanish America. = Diard Rayée, Home Ribbon, Mauritius Ribbon, Louisiana Striped, Red Rib-

bon, San Salvador, Seete, Striped Bamboo, Striped Mexican, Striped Preanger, Striped Singapore, Transparent, Deerr.
Striped Egyptian:—Barbados, Rept. 1905–7: 23, 1908. Trinidad, Bull. 18: 74, 1919.
Striped Fiji:—Java, from Australia, Wakker, 1896.
Striped Iscambine: = Tsimbic, Deerr.
Striped Issacs:—N. S. Wales, Colonial Sug. Co. permits planting certain districts, Int. Sug. Jour. 1: 506, 1899.
Striped Java:—Mauritius, Boname, 1898–9. [= Striped Cheribon.]
Striped Leyte:—Philippines. = Striped Ambos Camarines, Hines, Rev. 8: 153, 1915.
Striped Louisiana: = Striped Cheribon, Deerr.
Striped Mappoo:—Queensland, from Mauritius, 1878, Easterby.
Striped Mauritius:—India, Barber, Studies 2. [= Striped Cheribon.]
Striped Mexican: = Striped Cheribon, Deerr.
Striped Preanger: = Striped Cheribon, Deerr.
Striped Singapore: = Striped Cheribon, Deerr.
Striped Tanna:—Queensland, from Mauritius, 1878, Easterby. Mauritius, from Queensland, 1890, Agr. Dept. Bull. 2: 11, 1916. Barbados, Rept. 1917–19: 60. N. S. Wales, Colonial Sug. Co. permits planting, Int. Sug. Jour. 1: 506, 1899. = Big Ribbon, Guingham, Maillard, Otaheite Ribbon (Wray), Teboe Soerat (Java), Deerr. [The citations in the literature are not always clear between this and Striped Cheribon.]
Striped Tip:—Hawaii, Deerr.
Sucker:—Jamaica, Jour. Agr. Soc. 20: 12, 1916.
Sug:—Queensland, from Java, 1878, Easterby.
Sukii:—Jamaica, Bull. Bot. Gar. 3 (n. s.): 206, 1896.
Sukli:—India, Taylor; Woodhouse.
Sumatra:—Argentine, from Brazil, Zerban, 1916.
Sumatra Groen:—Java, Kobus, Med. 6, 1893.
Sumatra Paars:—Java, Kobus, Med. 6, 1893.
Sumatra Poetih:—Java, Kobus, Med. 6, 1893.
Sumatra Rood:—Java, Geerligs, Med. West-Java, 27.
Sumatra Wit:—Java, Geerligs, Med. West-Java, 27.
Sunnabile:—India, a group name, Barber, Studies 3. [See Sonabile and Sannabile.]
Surat:—[As used by Kruger = Soerat.]
Suretha:—North India, Barnes. [See Saretha.]
Surri:—India, Watts' Dict. 6(2): 70.
Surta:—India, Watts' Dict. 6(2): 67.
S. W.:—(As initials with numbers) Java, = Sempalwadak Seedlings, a series made in 1904 by crossing Batjan as staminate on Zwart Cheribon as pistilate parent. Arch. 17: 662, 1909. Jeswit, Med. 3, 1917. Hareveld, Med. 15, 1917.
T.:—(As initials with numbers) = Trinidad Seedlings, 1895 to 1904.
Tacuara:—Argentine, Rev. Tuc. 3: 339, 1913.
Tadjam Mata:—Java, from Sumatra, Wakker, 1896.
Talang:—Java, from Sumatra, Wakker, 1896.

Tamarah:—Queensland, from Mauritius, 1878, Easterby.
Tamarin:—Mauritius, from New Caledonia, 1870, Dept. Agr. Bull. 2:11, 1916. Boname, 1895, 1896, probably = Settlers. [The name comes from a locality in Mauritius.] Queensland, from Mauritius, 1902, Maxwell; Easterby. Natal, mentioned as a favorite cane, The Sugar Cane 9:322, 1877. Brazil, Sao Paulo; Sawyer. Argentine, from Brazil, Zerban, 1910. Porto Rico, Stahl, 1880; López Tuero. Demorara [as Tamarind], Harrison & Jenman.
Tambada:—Bombay, India, Knight, = Kare Rasadali.
Tambdi:—India, Watts' Dict. 6(2):74.
Tambiaba:—Guadeloupe, Boname, 1888, recently imported to Mauritius, from New Caledonia.
Tambiapin:—Mauritius, Boname, 1898–9.
Tambiola:—Mauritius & Reunion, from New Caledonia, Sagot 328.
Tangalite:—New Caledonia, Vieillard, 1863, Sagot 346.
Tangerang:—Java, from Java, Wakker, 1896; Kobus, Med. 6, 1893; Van Derventer Handb. 5:151, 1915; Soltwedel, fig. 10. Represents a medium stout reddish cane; internodes barrel shaped; nodes constricted; buds ovate.
Tangio:—Mauritius, from New Caledonia (Lavignac), Horne, 1869.
Tanna:—The Tanna Canes, Deerr. Light Tanna = White Tanna, Green Tanna, Malabar, and Yellow Caledonia. Striped Tanna = Big Ribbon, Daniel Dupont (in part), Guingham (in part), Maillard, Otaheite Ribbon (in part). Dark Tanna = Black Tanna. [All are said to resist Gum Disease.]
Tapara Buria:—Queensland, from Java, 1878, Easterby [See Japara.]
Tapoura Poé:—New Caledonia, Breslau, 1884, Sagot 344.
Teboe:—The Malay name (in Java) for sugar cane. As a prefix it has been disregarded in this list. Also written Teboo Tebu, Tebbou, Tibboo, Tiboo, Tiboe, Tibour, Tigboa.
Teelor:—Straits Settlements, Wray, = Egg Cane.
Tegal Waroe:—Java, from Java, Wakker, 1896.
Tek Chah:—Argentine, from Formosa, Rev. Tuc. 9(1):14, 1918.
Tekucha:—So. Africa, from Formosa, Choles.
Telfair:—Sagot 326.
Telor:—Java, from Riouw, Wakker, 1896. [See Teelor.]
Tengger:—Java, Oost-Java, Med. 9:19. Kobus, Med. 6, 1893.
Tereru:—India, Barber, Studies 1. = Teru.
Tergun:—Java, from Sumatra, Wakker, 1895.
Teru:—North India, Barnes; Barber, Studies 2, 3.
Tezal Warroe:—Mauritius, from Java, Horne, 1869. [See Tegal Waroe.]
Thirri:—India, Watts' Dict. 6(2):70.
Thoon:—Java, from English India, Kobus, Med. 48, 1893.
Thsiogan:—New Caledonia, Vieillard, 1863, Sagot 347.
Thun:—India, Watts' Dict. 6(2):62.
Tiambo:—Bahía, Brazil, The Sugar Cane 22:483, 1890. [See Tsiambo.]

Tiboe:—Queensland, from So. Sea Islands, 1874, Easterby. [See Teboe.]
Tiboo:—Mauritius, from New Caledonia (Lavignac), Horne, 1869. Jamaica, from Mauritius, 1882, D. Morris. [See Teboe.]
Ti Botti:—New Caledonia, Breslau, 1884, Sagot 340.
Ti Bou:—New Caledonia, Breslau, 1884, Sagot 338.
Ti Brou:—New Caledonia, Breslau, 1884, Sagot 341.
Ti Brou Opa:—New Caledonia, Breslau, 1884, Sagot 341.
Ti Ca Semba:—New Caledonia, Breslau, 1884 Sagot 342.
Ti Chigaka:—New Caledonia, Breslau. 1884, Sagot 340. [See Chigaca.]
Ti Grivailho:—New Caledonia, Breslau, 1884, Sagot 338.
Ti Ka Ti:—New Caledonia, Breslau, 1884, Sagot 338.
Tikona:—Mauritius, from New Caledonia (Lavignac), Horne, 1869.
Tilibi:—New Caledonia, Vieillard, 1863, Sagot 347.
Ti Ma:—New Caledonia, Breslau, 1884, Sagot 335.
Ti Mahoun:—New Caledonia, Breslau, 1884, Sagot 336.
Ti Mandou:—New Caledonia, Breslau, 1884, Sagot 340.
Ti Manguendon:—New Caledonia, Breslau, 1884, Sagot 335.
Timboe:—New Caledonia, Breslau, 1884, Sagot 336.
Ti M'N're:—New Caledonia, Breslau, 1884, Sagot 338.
Timor:—Java, Oost-Java Med. 26: 3; Kobus, Med. 6, 1893; Van Derventer, Handb. 5: 151, 1915.
Ti O:—New Caledonia, Breslau, 1884, Sagot 337.
Ti-One Pa:—New Caledonia, Breslau, 1884, Sagot 341.
Ti Ooeti:—New Caledonia, Breslau, 1884, Sagot 340.
Ti Oue:—New Caledonia, Breslau, 1884, Sagot 343.
Ti Ouegna:—New Caledonia, Breslau, 1884, Sagot 338.
Ti Ouependon:—New Caledonia, Breslau. 1884, Sagot 343.
Ti Poriman:—New Caledonia, Breslau, 1884, Sagot 343.
Ti Quiman:—New Caledonia, Breslau, 1884, Sagot 337.
Ti Rrré:—New Caledonia, Breslau, 1884, Sagot 342.
Tischiepa:—Mauritius, from New Caledonia (Lavignac), Horne, 1869.
Tita:—Brazil, = Imperial, Weller, The Sugar Cane 25: 187, 1893.
Ti Tentankoe:—New Caledonia, Breslau, 1884, Sagot 336.
Ti Tie:—New Caledonia, Breslau, 1884, Sagot 334.
Ti Tohou:—New Caledonia, Breslau, 1884, Sagot 334.
Ti Tonghio:—New Caledonia, Breslau. 1884 Sagot 340.
Ti Tshani:—New Caledonia, Breslau. 1884, Sagot 338.
Tip Canes:—Hawaii, Deerr.
Tjemang:—Java, from Bali, Wakker, 1896.
Tjepiring:—(With numbers) Java. Med. 7: 813, 1917.
Tjeribon:—Java, Kobus, Med. 6, 1893. [See Cheribon.]
Tjeribon Koening:—Java, Kobus, Med. 6, 1893.
Tjibaran:—Java, from Sumatra, Wakker, 1896.
Tjina:—Java, from Sumatra, Wakker, 1896.
Tjinoet:—Java, from Sumatra, Wakker, 1896.
Tjoerieng:—Java, from Bovenlanden Wakker 1896.
Tjoreng.—Java, from Sumatra, Wakker, 1896.
Tkouo:—Queensland, from So. Sea Islands Easterby.

To Aeho:—Society Islands, Cruzent, 1860.
To Avae:—Pacific Islands, Deerr.
Toeboe Mărafoli:—Borneo, Rumphius.
Toengkei:—Java, from Sumatra, Wakker, 1896.
Toetoeng:—Java, from Sumatra, Wakker, 1896.
Tombiamie:—Mauritius, from New Caledonia (Lavignac), Horne, 1869.
Tombiapa:—Mauritius, from New Caledonia (Lavignac), Horne, 1869.
To Oura:—Pacific Islands, Deerr.
Tora:—India, Watts' Dict. 6(2): 70.
Tourkoury:—Jamaica, from Mauritius, 1882, D. Morris.
To Patu:—Society Islands, Cruzent, 1860.
To. Ura:—Tahiti, Bennett, The Sugar Cane 6: 593, 1874. Australia, = Ribbon, Melmouth Hall.
To Ute:—Tahiti, Bennett, The Sugar Cane 6: 593, 1874; Cruzent, Simmons Trop. Agr. 1877. Queensland, from Society Island, Davidson, Easterby. Pacific Islands, = *Sac. Atrorubens*, Deerr. [= Djamprik.]
Tranchada:—Pernambuco, Brazil, Bull 3.
Transparent: = Ribbon, = Striped Cheribon, Deerr.
Treda:—India, Watts' Dict. 6(2): 66.
Treru:—India, Watts' Dict. 6(2): 67.
Trimotu:—Queensland, = Salangore, Easterby.
Trinidad:—Mauritius, Horne, 1869. Boname, 1896, 1898–9.
Troeboe:—Java, from Java, Wakker, 1896, Kobus, Med. 6, 1893; Soltwedel, fig. 28. Represents a slender dark-green cane with conspicuously swollen nodes. Characterized by a retained, abortive fleshy inflorescence that is used for food like Cauliflower. = *Sac. edule* Hassk. Queensland, from New Caledonia, 1870, J. Hill; Davidson, 1880, Easterby. [These descriptions call for a dark-colored cane evidently distinct from that of Java.]
Trunotu:—Queensland, from Society Islands, 1878, Easterby.
Tschiemie:—Queensland, Easterby.
T'Shiambe:—New Caledonia, Breslau, 1884, Sagot 344.
Tshiambo:—New Caledonia, Vieillard, 1863, Sagot 346.
Tsimbic:—Jamaica, from Mauritius, 1882, D. Morris. Louisiana, from Jamaica, Stubbs; Agee. = Striped Iscambine, Deerr.
Tsiambo:—Mauritius & Reunion, from New Caledonia, Sagot 328. Guadeloupe, Boname, 1888. Argentine = Fiambo. [See Tiambo.]
Tubu:—A native name for Sugar Cane, Rumphius.
Tumbia Mie:—New Caledonia, Breslau, 1884, Sagot 334.
Tumbia Sa:—New Caledonia, Breslau, 1884, Sagot 384.
Tunia:—India, Watts' Dict. 6(2): 69.
Uba:—Brazil, Moreiro, 1876, on page 6. Uba is mentioned under date of 1859. Mauritius, from Brazil, Horne, 1869. So Africa, Choles, Dept. Agr. Jour. 5, 1913, has superceeded all other canes. Argentine, from Natal. Rev. Tuc. 8(1): 14, 1918, Rev. Tuc. 9(9 & w): 144, 1919, Fawcett. = Kavangire. Queens-

land, = Yuba, = Yuban, Easterby. [Diamond, in Louisiana was in error in making Uba = Zwinga.] Jamaica, from Zululand, recommended by Earl Kitchner, Ann. Rept. 1917. Barber, Int. Sug. Jour. Jan. 1918 recognizes Uba = Ganna of India.

Uba, Purple Striped Sport:—Natal, 300 acres in cultivation, Int. Sug. Jour. 22: 300, June, 1920.

Uga:—A native name for sugar cane, Rumphius.

Ukh:—India, a class name used by Hadi for thin reed-like canes, Deerr.

Ula:—Java, from Malacca, Wakker, 1896.

Umoba:—So. Africa, Choles, a native Zulu name, = Green.

Uouo:—Natal, Pacific Islands, = Vachi, Deerr.

Utan:—Java, from Malacca, Wakker, 1896.

Uwala:—Louisiana, from Hawaii, Stubbs; Agee.

Vagabonde:—Demorara, Harrison & Jenman. Java, from Malacca, Wakker, 1896.

Vaihi:—Society Islands, Cruzent, 1860. Otaheite, Bennett, 1874. Pacific Islands, = Uo Uo, Deerr.

Vamboix:—Queensland, from Singapore, 1880, Easterby.

Vansaigari:—Bombay, India, Watts' Dict. 6(2): 73.

Vansi:—Bombay, India, Watts' Dict. 6(2): 73.

Vara:—Bombay (Ozanne), a class name, Watts' Dict. 6(2): 74.

V. D.:—(Initials with numbers) Java, Ledeboer, Med. 4: 452, 1917.

Vellai:—India, Barber, Studies 2.

Vendamukhi:—Bengal, India, Pusa, Bull. 83: 27, 1919.

Venezuelan Bourbon:—Trinidad, Williams, Bull. 18: 74, 1919. A reddish-green cane.

Verde das Antillas:—Argentine, from Brazil, Zerban, 1910.

Verde de Jujuy:—Argentine, Rev. Tuc. 9: 133, 1919; Fawcett, desc. and fig.

Verde Gruesa:—Argentine, from Brazil, Zerban, 1910.

Verde Zic-zac:—Porto Rico, Stahl, 1880. [Possibly the Zig-zag Green Cane figured by Tussac which Mr. Noel Deerr has seen in Porto Rico.]

Vermehla:—Brazil, ≐ Bois Rouge, Deerr.

Verte Jardin:—Mauritius, Boname, 1898–9.

Verte Pays:—Mauritius, Boname, 1895, 1898–9.

Veu:—Tahiti, Bennett, The Sugar Cane 6: 593, 1874.

Vico:—Demorara, Harrison & Jenman. Java, from Malacca, Wakker, 1896.

Vilaine:—Mauritius, Boname, 1898–9.

Vinagre de Sao Simao:—Argentine, from Brazil, Zerban, 1910. = Tebu Djamprik; leaves purple; also seen in Peru.

Violacea:—Brazil, Moreira, 1876, = Roixa.

Violet:—Silleman, Manuel, 1833, cites Tussac and Humboldt & Bonpland. Australia, Melmouth Hall, The Sugar Cane 6: 588, 1874, "Abounding in cane itch." Jamaica, MacFadyen, 1830. = Batavian Cane, Black Cane, Claret Cane, Imperial and Mont Blank [includes Black Cheribon, perhaps others].

Violet Ribbon:—Australia, = Tabor Socrat of Java (Diard), Angus Mackay. Demorara, Harrison & Jenman. [= Striped Cheribon.]

Violet Salangore:—Trinidad, provisional name proposed by Mr. Purdie, The Sugar Cane 11:585, 1879.

Violet Tita:—Brazil, Weller, The Sugar Cane 25, 187, 1893.

Vitua-haula:—Jamaica, from Mauritius, 1882, D. Morris. Demorara, Harrison & Jenman. Louisiana, from Jamaica, Stubbs. Java, from Malacca, Wakker, 1896. = Louzier, Moquette. Arch. 6:292, 1898.

Vopa:—New Caledonia, Breslau, 1884, Sagot 333.

Vulu Vulu:—Jamaica, from Mauritius, 1882, D. Morris. Demorara, Harrison & Jenman. Louisiana, from Jamaica, Stubbs, Agee. Java, from Malacca, Wakker, 1896.

W.:—(Initials with numbers) Barbados, Rept. 1905–7:33, Antigua, Watts, Rept. Lee-Ward Islands, 1916–17.

Wagaisy:—Mauritius, from New Caledonia (Lavignac), Horne, 1869.

Waltons Seedling:—Barbados, Rept. 1912–14:54, 1914.

Wanga Aloes:—Java, Kobus, Med. 6, 1893.

Wanga Gros:—Java, Kobus, Med. 6:1893.

Wanga Warottan:—Java, Kobus, Med. 6, 1893.

Wansia:—Bombay, India, Knight, =Khadya.

Waphendnow:—Jamaica, from Mauritius, 1882, D. Morris.

Waterford:—(With numbers) Barbados, Rept. 1909–11:23. [Probably = W. See above.]

Weri:—Java, Kobus, Med. 6, 1893.

West Indian Creole:—Demorara, Harrison & Jenman, = Barbados Native [= Creole].

Whitealoran:—Philippines, from Australia, Hines, Agr. Rev. 8:158, 1915.

White Aboe:—Mauritius, Horne, 1869, = White Rappoe.

White Bamboo:—Queensland, from Mauritius, 1877, Maxwell; Easterby. Louisiana, from Jamaica, Agee.

White Bombay:—India, Watts' Dict. 6(2):60.

White Cane:—Java, Kajenbrink, 1870. = Teboe Pring.

White Cheribon: = Light Cheribon, Deerr. = Crystalina.

White Creole:—Jamaica, West Ind. Bull. 6:339, 1906.

White Elephant:—Jamaica, Bull. 4:227, 1897. = Caledonian Queen, Java, Hope [= Crystalina].

White Luzon:—Philippines, Hines, Agr. Rev. 8:153, 1915.

White Manila:—Java, Deerr.

White Mauritius:—India, Barber, Mem. Dept. Agr. 7:25, 1915. [= Crystalina?]; Woodhouse, = Otaheite. Demorara, = Salangore, Harrison & Jenman.

White Mexican:—Queensland, from Honolulu, 1906, Easterby. Louisiana, Agee.

White Native:—Negros, Philippines, Wakker.

White Queen:—So. Africa, Choles.

White Rappoe:—Mauritius, = White Aboe, Horne, 1869.

White Sport:—Barbados, Rept. 1905-7: 34.
White Striped Bourbon: = Green Ribbon, Deerr.
White Surati:—Bombay, India, Knight, = Khajuria.
White Tanna:—Mauritius, a sport from Striped Tanna at Pamplemouses, also introduced as Green Tanna, from N. S. Wales, 1895, Dept. Agr. Bull. 2, 1916. = Yellow Caledonia, = Malabar, Deerr.
White Transparent:—Jamaica, = Mont Blanc, = the Otaheite introduced by Capt. Bligh, West Indian, Bull. 8: 26, 1907. Demerara, = Caledonian Queen, Mamuri, Rappoe, Hope, Light Java, Cheribon, Blue Cane, Crystalina, Rose Bamboo, Light Purple, Harrison & Jenman. = Crystalina, Deerr.
Wiehe:—(With numbers) Queensland, from Mauritius, 1901, Easterby.
Wit:—Java, = Bamboe, Pring, Rotan, Poutih, Sagot 326.
Wit Carp:—(With numbers) Java, Harreveld, Med. 15, 1917.
Wit Ceram:—Java, Wilbrink & Ledeboer, Med. 6: 86, 1911.
Wit Manilla:—Java, Wilbrink & Ledeboer, Med. 6: 86, 1911. [See White Manila]; Harreveld, Med. 15, 1917; Van Derventer Handb. 5: 148; Jeswit, full desc. Med. Deel VI. 13: 392, 1916.
Wit Mappoe:—Java, Geerligs, Med. West-Java, 27.
Woelong:—Java, from Java, = Assep., Wakker, 1896; Gonsalves, = Black Cane.
Woengoe:—Java, Kobus, Med. 6, 1893.
Woengoe Soerat:—Java, from Java, Wakker, 1896.
Wolmer:—(With numbers) Queensland, from Mauritius, 1901, Easterby.
Yasquia:—Jamaica, from Mauritius, 1882, D. Morris.
Yellow:—Louisiana, = Otaheite, Stubbs
Yellow and Green:—Mauritius, from West Indies, Horne, 1869.
Yellow and Red Striped:—Bahía, Brazil, The Sugar Cane 22: 483, 1890.
Yellow Bamboo:—Hawaii, Eckert, Bull. 7, 1905, Deerr & Eckert, Bull. 26: 19, 1908.
Yellow Bourbon:—Evans, The Sugar Planters Manual 37, 1847. "Often confounded with Yellow Otaheite."
Yellow Caledonia:—Louisiana, from Hawaii, Stubbs; Agee. Hawaii, = White Tanna, Green Tanna, White Bamboo and Malabar. Deerr & Eckert Bull. 26 :14, 1908.
Yellow Cane:—Queensland, Mackay, The Sugar Cane 7: 187, 1875.
Yellow Egyptian:—Barbados, Rept. 1905-7: 23, 1908.
Yellow Java:—Went, West Ind. Bull. 12(4): 556, 1912; probably = Bourbon.
Yellow Mauritius:—Queensland, Davidson, 1880, from Singapore, 1878, Easterby. [= Otaheite.]
Yellow Nepaul:—Wray.
Yellow Otaheite:—Evans, The Sugar Planters Manual 37, 1847, "often confounded with Yellow Bourbon." Hawaii, Deerr & Eckert Bull. 26, 24, 1208. = Otaheite.
'ellow Singapore: = Crystalina, Deerr.

Yellow Tahitian:—Australia, Melmouth Hall, The Sugar Cane 6: 588–9, 1874. The first cane cultivated in Australia, from Tahiti, 1817 by Th. Scott. Totally distinct from Otaheite of West Indies; probably = Irmotu.
Yellow Tip:—Hawaii, Deerr.
Yellow Violet:—Jamaica, Wray. [= Crystalina.]
Yerra:—Madras, India, Int. Sug. Jour. 2:469, 1900.
Yon Tan San:—Argentine, from Formosa, Rev. Tuc. 9(1):14, 1918; 9:147, 1919. Immune to Yellow-Stripe Disease, Fawcett, El Mundo Azucarero, Feb. 1920, p. 206.
Ysaquia:—Louisiana, from Jamaica, Stubbs: Agee. [See Yasquia.]
Yuba:—India, Barber. Studies 1, 2. Queensland, = Uba, Easterby.
Yuban:—Queensland, from So. Africa, = Uba, Maxwell, Easterby.
Yumbi:—New Caledonia, Breslau, 1884, Sagot 331.
Yunscao:—Argentine, from Brazil, Zerban, 1910.
Zepara:—Mauritius, from Java, Horne, 1869. [See Japara.]
Zepara Bina:—Mauritius, from Java, Horne, 1869.
Zig-zag:—Pernambuco, Brazil, a local seedling from Cayanna seed [Otaheite], Int. Sug. Jour. 1:378, 1899.
Zwart Borneo:—Java, Harreveld, Med. 3:1032, 1919.
Zwart Cheribon:—Java, Wilbrink & Ledeboer, Med. 6:86, 1911. [= Black Cheribon.]
Zwart Manilla:—Java, from Manilla, Wakker, 1896; Wilbrink & Ledeboer, Med. 6:86, 1911; Van Derventer, Handb. 5:149, 1915. Dark-red leaf sheath with brown bristles.
Zwart Muntock:—Java, Kobus, Med. 6, 1893; Van Derventer, Handb. 5:149, 1915; Harreveld, Med. 12, 1708, 1918.
Zwinga:—Louisiana, from Japan, 1877, identical with No. 24 from Brazil or Uba, [a mistake], John Diamond. [= Japaneese Fodder Cane.] Argentine; (From Louisiana) Rev. Tuc. 6(12): 516, 1916; Rev. Tuc. 9:146, 1919, Fawcett.

BIBLIOGRAPHY.

A LIST OF THE PRINCIPAL PUBLICATIONS CONSULTED IN PREPARING THE ABOVE LIST OF CANE VARIETIES.

AGEE, H. P.

Sugar Cane Seedlings, La. Exp. Sta. Bull. 127, 1911, also published in the Louisiana Planter, gives a list of the cane varieties cultivated at the Louisiana Sugar Station, Audubon Park, New Orleans, usually with mention of the country from which they came.

ANNUAL OF SCIENTIFIC DISCOVERY, 1851.

Contains a list of cane varieties cultivated in Louisiana. It seems to have been copied from Fleischman's Report, 1848, which see.

ARCHIEF VOOR DE JAVA SUIKERINDUSTRIE.

Founded in 1893 and still being issued. The entire volumes Nos. 1–8, 1893 to 1900, have been indexed in full for cane varieties, the later volumes only in part.

BAHÍA, BRAZIL.

An article on "Cane Varieties Cultivated in Bahía, at Institute Bahiano de Agricultura." Taken from Revista de Agricultura and republished in the Sugar Cane 22: 483, 1890. Twenty-two kinds are mentioned.

BARBADOS.

Reports Imp. Dept. of Agr., 1905 to date; earlier reports not seen. These contain a vast amount of experimental data by Bovell but mostly in regard to new seedling canes.

BARBER, C. A.

Studies in Indian Canes 1. The Punjab Canes. Mem. Dept. Agr. India 7 (No. 1), May, 1915. Includes a full discussion of the taxonomic characters used in describing canes.

Studies in Indian Canes 2. Mem. Dept. Agr. India, 8 (No. 3), July, 1916. Largely devoted to sugar cane seedlings.

Studies in Indian Canes 3. The Classification of Indian Canes with Special Reference to the Saretha and Sunabile Groups. Mem. Dept. Agr. India (Bot.) 9 (4), May, 1918.

Progress of the Sugar Cane Industry in India during the years 1916 and 1917. Agr. Inst. Pusa, Bull. 83, 1919.

BARNES, J. H.

Sugar and the Sugar Cane in the Guardaspur District. Agr. Inst. Pusa. (India), Bull. 69, 1918.

BENNET, DR.

Varieties of cane growing in Tahiti. See foot note, The Sugar Cane 6: 593, 1874. Eight varieties are mentioned.

Boname, Ph.
Culture de la Canne a Sucre en Guadeloupe. Paris, 1888. Report Ann. Sta. Agronomique, Mauritius, 1895, 1896 and 1898–9. His subsequent reports up to 1910 give data on seedling canes only.

Bouton, Louis.
Rapport Presenté a la Chambre d'Agriculture sur les diverses especes de Cannes á Sucre Cultivées a Maurice, 1863. An important paper giving synonymy and descriptions of the canes cultivated in Mauritius at that time, correspondence with Diard, &c. A copy is in New York Public Library.

Bovell, J. R.
See Barbados Repts. Also Recent Experience with seedling and other canes, West Ind. Bull. 2(1):25, 1901. Gives history of varieties in Barbados.

Brisbane Botanical Gardens.
Sugar Cane in the Brisbane Botanical Gardens. The Sugar Cane 2:104, 1870, 15 varieties are listed.

Choles, Herbert J.
Sugar Cane in South Africa. Agric. Dept. Union of So. Afric. Journal 5:188, 1913. Gives history of cane introductions.

Clark, G., and S. M. Hadi.
Sugar Cane at the Partabgark Exp. Sta. (India). Agr. Research Inst. Pusa, Bull. 13, 1908.

Colson, Leon.
Culture et Industrie de la Canne á Suere aux Iles Hawaii et a la Reunion, 1905.

Cousins, H. H.
Rept. Jamaica Sugar Exp. Sta. 1905–6. 2nd Rept., years 1906–7. 3d Rept., 1808–10. Seedling Canes in Jamaica, West Ind. Bull. 8:26, 1907. Brief history of variety introductions.

Cross, W. E.
Las Cañas de Java en Java. Rev. Tuc. 9:152, 1919. Important shipment of Sugar Cane, La. Planter, Mch. 8, 1919.

Cruzent.
An account of the Society Islands, 1860. See in Simmons' Tropical Agriculture, 1877.

Davidson, J.
In Rept. Sugar Industry of Queensland by H. L. Roll, 1880. This is an important paper giving good descriptions of 29 varieties of cane, grown at the Mackay estate, of which Davidson was manager. [Indexed from a M. S. copy kindly loaned by Mr. Noel Deerr.]

Deerr, Noel.
Cane Sugar, 1911. The best and most complete modern treatise on sugar cane.

Deerr, Noel, and C. F. Eckert.
Varieties of Cane with Special Reference to Nomenclature. Hawaii Sugar Sta. Bull. 26, 1908. The first successful attempt to untangle sugar-cane synonymy.

DEMORARA.
Journal of the Board of Agriculture of British Guiana. (Vols. 7 to 12 are partly indexed, only part of the numbers seen.) [See also Harrison and Jenman.]

DYMOND, JOHN.
Our Varieties of Sugar Cane. A paper read before the Louisiana Sugar Planters' Association. The Sugar Cane 18: 460, 1886. Gives the history of cane introductions.

EASTERBY, HARRY T.
Varieties of Sugar Cane in Queensland. Queensland Bureau of Sugar Expt. Sta. Bull. 2, 1915. A long list of cane introductions, giving date and country of origin with some descriptive notes and synonymy.

ECKERT, C. F.
Varieties of Cane, Hawaii Sugar Sta. Bull. 10, 1905. Comparative test with varieties of sugar cane. Hawaii Sugar Sta. Bull. 17, 1906. [See also Deerr and Eckert.]

EVANS, DR. W. J.
The Sugar Planters' Manual, London, 1847. Contains notes on six varieties.

FAWCETT, G. L.
Algunas Descripciones Botánicas de las Variedades de Java y Otras Cañas. Rev. Tucuman, 6(12): 509, 1916.
Algunas Descripciones Adicionales de Variedades de Caña. Rev. Tuc. 9(9.10): 129, 1919. Good descriptions and figures.

FERNÁNDEZ DEL CAMPO, LUIS.
Cultivo de la Caña de Azúcar, Mexico, 1913. Only four varieties mentioned.

FLEISCHMAN, CH. L.
U. S. Patent Office Rept. 1848. An account of a trip to Louisiana to investigate the sugar industry. The discussion of cane varieties is very good. There are six colored plates of cane varieties by Fleischman in which the buds are carefully drawn, and two anatomical plates by Corda, the Austrian botanist and mycologist, whom Fleischman chanced to meet in New Orleans.

GEERLIGS, PRINSEN.
Analyses Van Rietvarietietan Uit den Proeftum. Med. Proefsta. West-Java te Kagok-tegal, No. 27. Also in Archief fer Suik. Ind. 4: 1141, 1896. A long list of varieties with country of origin. The list includes 133 names. Most of them are also found in Wakker's list from the Oost-Java Proef. Sta.

GONSALVES, T. M.
The Black Sugar Cane of Java. Taken from a pamphlet by T. M. Gonsalves of Cheribon. The Sugar Cane 15: 361, 1883.

GODOY, CYRO.
Cultura de Canna de Assucar. Bol. de Agr. de Sao Paulo (Brazil), 16(8): 727, 1915.

GORKUM, DR. NICOLAS VAN.
Relatorio sobre os resultados obtidos, &c. Boletim do Min. da Agric. Ind. E. Com. 2, Abril, 1915.
GORKUM, DR. NICOLAS VAN, AND DR. LUIZ DE WAAL.
Situacao da Cultura da Canna de Assucar e da Fabricacao do Assucar Na Zona Agricola de Campos (Brazil), 1913.
HALL, MELMOTH.
History of Sugar Cane in Australia Down to 1873. The Sugar Cane 6: 588, 1874.
HARRISON, J. B.
Results of Recent Scientific Researches into the Agricultural Importance of the Sugar Cane. The Sugar Cane 29: 419, 1897. Synonymy of variety names is given.
Average Results of Nine Crops—Old Varieties. Rept. Brit. Guiana Bot. Gar. 1893–4–5. Also in The Sugar Cane 29: 414, 1897.
HARRISON AND JENMAN.
Descriptions of Varieties of Cane in the Botanical Gardens of British Guiana. The Sugar Cane, Apr. 1, 1892.
HILL, WALTER.
See under Angus Mackay.
HINES, CLEVE W.
History of Cane Varieties in the Philippines. Phil. Agr. Rev. 8(3): 152, 1915.
HORNE, JOHN.
Report Royal Botanical Gardens, Mauritius, 1869. See also The Sugar Cane 2: 668, 1870. A long list of varieties with country of origin. A list of canes imported into Mauritius from Egypt. New South Wales, Queensland, New Caledonia &c. (including Brazil). The Sugar Cane 2: 223, 1870.
The New Varieties of Cane in Mauritius. The Sugar Cane 3: 209, 1871. Gives chemical data, &c.
INDIA.
Papers Respecting the Culture and Manufacture of Sugar in British India, London, Dec. 18, 1822. A thick quart volume with a vast mass of local information. Issued by the East India Co.
East Indian Sugar Canes, from the Indian Agriculturist. The Sugar Cane 15: 644, 1883.
Sugar Growing in Hospeapore (Punjab). From the Indian Agriculturist, The Sugar Cane 15: 594, 1883. (See also Barber, Barnes, Clark & Hadi, Knight and Watts.)
INTERNATIONAL SUGAR JOURNAL.
Manchester, England, founded in 1899 and still published. It is a continuation of the periodical The Sugar Cane, which had been published under that name for thirty years.
JAMAICA.
Bulletins of the Botanical Department of the Botanical Garden New Series and of the Sugar Experiment Station contain

much matter on cane varieties. [See also MacFadyen, and Sir D. Morris.]

JESWIT, DR. J.

A series of valuable Descriptive articles on cane varieties in Med. van het Proef St. v de Java. Suiker-Industrie. See Nos. 5 and 13, 1916, Nos. 3, 8, 12, 17, 1917, and No. 5, 1918.

KNIGHT, J. B.

Sugar Cane, Its Cultivation and Gul Manufacture. Dept. Agr. Bombay, Bull. 61, 1914.

KOBUS, J. D.

Verslag Omtrent de Resulaten Verkregen van den aanplant van verschellendende Rietsoorten in het Jaar 1892–93. Med. Oost-Java Proef St. N. S. 6.

Also in Archief, 2, 1894. Verslag Omtrent den Toestand der Aanplanting van English Indische Reitvarieteiten. Med. Oost-Java Proef St. 48, 1893.

Overzicht van het Verloop der Importatie, plannen van Riet-soorten of een eeland buiten Java. Archief, 2: 664, 1894.

KRAJENBRINK, M. J. A.

Researches on the Saccharine Richness and Yield of Different Varieties of Sugar Cane in Java, from Jour. de l'Agric. des Pays Chands. The Sugar Cane 2: 192, 1870.

KRUGER, W.

Das Zuckerrohr und sine Kultur, 1899. A general work on sugar cane mainly based on experience in Java. Has colored plates of varieties.

KUNTH.

Synopsis Plantarum Aequinoctialum. Voyge de Humboldt and Bonpland, Vol. 1. Contains references to a few cane varieties.

LÓPEZ TUERO, FERNANDO.

Caña de Azúcar, Porto Rico, 1895. A general treatise on cane growing with discussion and description of varieties occurring in Porto Rico.

MACFADYEN, DR. JAMES.

In Hookers Bot. Misc. 1: 95, 1830. A most interesting account of cane culture in Jamaica with historical data regarding varieties.

MACKAY, ANGUS.

The Sugar Cane in Australia, 1870. Cane descriptions are by Walter Hill, the Director of the Brisbane Botanic Garden.

Sugar in Australia, The Sugar Cane 7: 187, 1875.

MCDONALD, JOHN.

Concerning Canes (Queensland). The Sugar Cane 14: 423, 1882.

MURITIUS.

See Leaflets 1 to 10; Annual Reports; Bulls. Sta. Agronomique 9 to 26; Bulls. Dept. of Agriculture; Reports of Botanical Garden by John Horne (only seen as reprinted in The Sugar Cane). [See also John Horne and Ph. Boname.]

MAXWELL, WALTER.
Ann. Repts. Bureau of Sugar Exp. Stations, Queensland, 1903–4, 1907–8.

MOREIRA, NICOLAO JOAQUIN.
Relatorio Sobre a Pretendida Enxertia da Canna de Assucar. Río de Janeiro, 1876.

MORRIS, SIR DANIEL.
New Sugar Canes for Jamaica, The Sugar Cane 15: 149, 1883. A list of canes received from John Horne, Director of the Mauritius Botanical Garden in Oct. 1882. [In Wardian Cases.] Forty-four kinds are listed. It is remarkable how many of them are under names not used in Mauritius.

The New Orleans Exposition, 1883; The Sugar Cane 17: 153, 1885. An editorial account of 58 varieties of cane exhibited from Jamaica by Sir Daniel Morris.

MYSORE AGRICULTURAL CALENDAR.
A short note on Sugar Cane Cultivation, pp. 20–22, 1915.

NATAL.
The Sugar Cane 9: 322, 1877. Notes on a few varieties of cane taken from the Natal Mercury. [See also Leon Colson.]

OOST-JAVA PROEF ST.
Mededeeling Nos. 1–49, 1887–1893. [See general index for cane variety names.]

PHILIPPINE AGR. REV.
6 (No. 12). Ann. Rept. Bureau of Agr. 1912–13. [See pp. 616–619, for cane varieties.]

PORTER, GEO. R.
The Nature and Properties of the Sugar Cane, 1843. A general work on sugar cane culture. The discussion of varieties is unsatisfactory.

PERNAMBUCO.
Bull. 3 da Estacao Exp. de Canna de Assucar.

PURDIE.
New Varieties of Cane. Trinidad, The Sugar Cane 11: 585, 1879.

ROBERT, HENRI.
Sugar Cane Varieties in Mauritius. Dept. of Agr. Mauritius Bull. 2, Statistical Series, 1916

ROCK, J. F.
Board of Agric. & Forestry, Hawaii, Bull. 2, List of Plant Names. includes some cane names.

REVISTA INDUSTRIAL Y AGRÍCOLA DE TUCUMÁN (ARGENTINA).
Vols. 1–9. Contains much valuable information on cane varieties.

RIDLEY, H. N.
History of Economic Plants (in Straits Settlements). Straits & Federated Malay States Agric. Bull. 4: 311, 1905.

ROXBURGH, WM.
Flora of India, Vol. 1, 1832. Gives quite an account of the sugar industry and describes eleven species of *Saccharum*, mostly destinguished by floral characters.
RUMPHIUS.
Herbarii Amboinensis 5: 186, 1747. Describes sugar cane under the name *Arundo Saccharifera*, discusses sugar-cane culture and mentions three agricultural varieties.
SAGOT, P.
Manuel Pratique des Cultures Tropicales, 1893. Gives a long general discussion of cane varieties in which he seems to follow Delteil. He also gives two long list of New Caledonia canes, one from a set of unpublished colored plates made by M de Breslau in 1884. Another by Vieillard taken from Vieillard et Deplanche Essais sur la Neuville-Caledonie, Paris, 1863.
SAWYER, FREDRIC H.
Estudio Sobre a Industria Assucareira no Estado de Sao Paulo (Brazil), Segundo Edicao, 1908.
SCARD, F. J.
Some Experiences with Seedling Canes in British Guiana. West Ind. Bull. 1(4): 380, 1890.
SCHLEH, EMELIO J
La Caña de Azúcar en Tucumán (Argentina), 1909.
SCHLEIFFER, S. A.
Sugar Production Among Small Settlers in Upper Clarendon (Jamaica). Jour. Agr. Soc. Jamaica, 20: 12, 1916.
SILLIMAN, PROF BENJ.
Manual on the Cultivation of Sugar Cane, and the Fabrication and Refinement of Sugar, 1833.
SIMMONDS, P. L
Tropical Agriculture, 1877. Includes an account of the Society Islands by M. Cruzent, 1860 in which eight kinds of cane are mentioned.
SMITH, ERWIN F.
Bacteria in Relation to Plant Diseases. Vol. III, 1914. Discusses varieties in relation to Gum Disease and Sereh.
SMITH, LONGFIELD.
Repts. St. Croix Exp. Sta., 1911–1915 (Virgin Islands).
SOLTWEDEL, FRIEDRICH.
Formen and Farben van *Saccharum officinarum*. After Soltwedels death these thirty colored plates were published in Berlin, 1892, by Benecke, his successor as Director of the Oost-Java Proefstation at Pasoeroran with a few notes but no full descriptions. The color and shape of these canes is well reproduced but the buds are carelessly drawn.
STAHL, DR. AGUSTIN.
La Enfermedad de la Caña de Azúcar in Puerto Rico, 1880. A full account of the disease which first appeared at Mayagüez in 1872. Mentions twenty-three varieties including those

introduced to combat the disease. Includes the report of the Commission appointed to investigate this cutbreak consisting of Stahl, Dr. D. C. Grivot, Grand-Court and José Julián Acosta. This report was also published separately in 1878.

STUBBS, WM. C.
Sugar Cane, 1900. A general work on sugar-cane culture in which an attempt is made to straigten out synonymy.

SUGAR CANE, THE.
A periodical published for thirty years 1869 to 1899 and since continued as the International Sugar Journal.

TAYLOR, C. SOMERS.
Notes on Experiments with Sugar Cane at Sabour (India). Agr. Inst. Pusa, Bull. 37, 1913.

TRINIDAD.
Bulletins of the Dept. of Agr. of Trinidad & Tobago. Vols. 14–18, 1915–1919. Proc. Agr. Soc. Trinidad & Tobago. Vols. 11 to 19. (The earlier Trinidad publications have not been seen.)

TUSSAC, F. R.
Flore des Antilles, Vol. 1, 1808. A set of this rare work with large colored folio plates is in the New York Public Library. Tussac was a French Botanist living in Haiti at the time of the black revolt in that island. He escaped to Jamaica where he continued his work. He gives an interesting account of cane culture in Jamaica with references to conditions in Haiti. He gives colored illustrations of four cane varieties all said to be brought from Tahiti.

VAN DERVENTER, W.
Hanboek voor de Suikerriet (Culture) En de Reet Sucker Fabricage of Java. Deel. 5, 1915. It is unfortunate that this most recent, authoritative general work on sugar cane culture is not available for those who do not read Dutch.

VAN HARREVELD, J.
Statistick van de verbreiding en de Productive der Rietsoorten in Oogst 1914, Med. Java-Suikerindustrie 12, 1918.

WAKKER, DR. J. H.
Onderzoek der Varietien. Mededieligen Oost-Java Proefst. 19, 1896. Also Archief. 4: 49, 1896. A list of 413 varieties with country of origin and chemical data.

WALTERS, ALBERT.
The Sugar Industry of Mauritius, 1910.

WATTS, FRANCIS.
Imp. Dept. Agri. Report Sugar-Cane Experiments in the Leeward Islands, Antigua and St. Kitts. Nevis, 1916–18, 1919.

WATTS, GEORGE.
Dictionary of the Economic Products of India, Vol. 6(2), 1893. A vast mass of data (pp. 1–380) on sugar cane under the heading "Saccharum."

WELLER, F.
The Sugar Cane in Brazil, taken from the Revista de Agricultura, The Sugar Cane 25: 187, 1893.
WEST INDIAN BULLETIN.
An Agricultural periodical published since 1902 and still continued.
WOODHOUSE, E. J.
Distinguishing Characters of Sugar Canes Cultivated at Sabour. (India). Mem. Dept. Agr. India. 7(2). Apr. 1915.
WRAY.
The Sugar Cane. A general work on sugar cane mostly based on practical experience in Jamaica and India.
YODER, P. A.
Sugar Cane Culture for Sirup Production in the United States. U. S. Dept. Agr. Bull. 486, Mch. 1917.
ZERBAN, F.
Las Variedades de Caña en la Estación Experimental. Resultados del Primer Año. Revista Ind Y Agr. de Tucumán (Argentina) 1(3) · 16, 1910. Gives a list of 75 kinds imported from Brazil.

Sixteen hundred and ninety-five names are included in the above list. This very considerable number of cane varieties (or at least varietal names) would be grouped by modern Botanical writers under only two species, *Saccharum spontaneum L.* and *S. officinarum L.*, the numerous other specific, subspecific and varietal names that have from time to time been proposed being reduced to synonymy. The first of these species would include the slender canes of Northern India and Japan while to the second would be referred all of the southern tropical varieties Whether this classification is really correct can only be determined by a more extended, detailed, comparative study of sugar cane inflorescences than has yet been given. *Saccharum spontaneum* occurs abundantly in nature as a widespread, exceedingly variable species having its center of distribution in India but also occurring in many of the East Indian Islands. No species of true *Saccharum* are indigenous in America, the nearest South American relatives having characters sufficiently distinct to warrant their removal from the genus. *Saccharum officinarum* on the other hand is not known to occur in Nature, the species being entirely based on cultivated forms. This gives weight to the argument of those who contend that all of the cultivated sugar canes are really descended from extreme forms of the widely variable *S. spontaneum*, which in the wild state as shown by Barber includes forms showing practically all of the characters by which we distinguish between the different cultivated kinds. Be this as it may

the group of slender North Indian canes now in cultivation is sufficiently distinct from the others in agricultural characteristics. From their vigor and productiveness, and especially from their immunity to many of the worst cane diseases, they represent a very important factor in the hands of the intelligent plant breeder. Kobus, in Java, is the only one so far who seems to have realized their great value. These Indian canes are divided by Barber (Studies 3) into two quite distinct groups named after two of the leading kinds, the Saretha and the Sunnabile groups. To the first belong the tall, slender canes with drooping leaves, including Uba, the Japanese Zwinga and Chunnee, the cane used by Kobus in his crosses. The second group would seem to include the old Creole cane, which is shorter and somewhat stouter and with strictly erect leaves. To what extent the valuable characteristics of these Indian canes are shared by the two groups is not known. The Creole at least was not remarkable either for tonnage or disease resistance.

Sufficient emphasis has already been given to the great probability that many of the above names are synonyms; and to the chances for a wide distribution of favorite varieties from the long voyages made by Malay sailors and their habit of carrying sugar cane as part of the provision for the crew. The fact remains, however, that the groups of varieties from different regions often seem to have certain characteristics in common Thus the Java canes, including as they do the three great commercial Cheribon varieties, probably represent the group of kinds that is richest in sugar. The New Caledonia canes on the other hand, including varieties like Yellow Caledonia, Striped Tanna and Cavengirie, show a tendency to great vigor and productiveness but with rather low sucrose. The New Guinea and the Borneo canes also seem to show certain special tendencies. Of the long list of canes brought from Sumatra to Java none seem to have gotten into general cultivation. The Red Fiji has proved immune to Sereh and to be a very useful parent in the making of crosses. All of these facts should be studied and carefully considered by the cane breeder in selecting his parent stocks.

If this list serves any useful purpose it will be in the calling of attention to the urgent need for careful taxonomic studies of all these old kinds in order to sift our synonyms and aid in the selection of useful kinds for breeding purposes and for farther and more extended trials under varying conditions. Some of the earlier descriptions are very useful and serve to identify the variety in question with little chance for doubt. In most cases however, they are

practically valueless, being little more than notes on color. Few of the older writers paid attention to bud characters. Among modern writers there are two whose work stands out preeminently—Jeswit in Java and Barber in India. They have both followed the usual methods of modern botanical taxonomy with the result that cane varieties can be as certainly recognized from their descriptions as can flowering plants from a good botanical manual. Fawcett in the Argentine has also done most excellent work along these same lines. If all those having access to collections of named cane varieties would give them a little critical study and publish descriptions along the lines followed by Barber, Jeswit and Fawcett we would soon be in a position to clear up the cloud of doubt that has for so long hung over the use of cane-variety names.

The labor of getting together this list of names can hardly be called a contribution to knowledge. It is rather intended to point out our lack of knowledge regarding most of these kinds each one of which has been well enough adapted to its local conditions and has had sufficient merit to have established itself in the primitive agriculture of the region of its origin. They are not recently produced seedlings selected by the whim of this or that plant breeder, but most of them have persisted for generations through the half-conscious selection of practical agriculturists. Evidently they have filled some local need. For this reason if no other they should receive more serious attention than has been given them during the past twenty years by either cane breeders or plantation managers. The breeding of new seedlings is useful and should by all means be continued, but it should not cause us to neglect the study of these older kinds which represent the best breeding results of all the past ages and from which much more than nine-tenths of the world's cane sugar is still produced.

PUBLICATIONS OF THE YEAR (1919-1920).

(PUBLISHED OR IN PRESS.)

Circular No. 26.—Antrax, por J. Bagué

Circular No. 28—The Cultivation of Citrus Fruits in Porto Rico, by F. S. Earle.

Circular No. 29.—La Morrina Negra, por J. Bagué.

Circular No. 30.—El Mejoramiento de Nuestras Siembras por la Selección, por E. E. Barker.

Bulletin No. 24—Citrus and Pineapple Fruit Rots, by J. Matz.

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CHANGES WROUGHT IN THE GRAPEFRUIT IN THE PROCESS OF MATURATION

PART I—NATURAL CHANGES.

BY

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BUREAU OF SUPPLIES, PRINTING, AND TRANSPORTATION
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CHANGES WROUGHT IN THE GRAPEFRUIT IN THE PROCESS OF MATURATION.

INTRODUCTION.

In the year 1911 the national pure-food officials conducted an investigation to determine to what extent was the suitability of citrus fruits for human consumption affected by the state of maturity of the fruit. This was necessary on account of the large amounts of immature citrus fruit with which Florida and California were flooding the market. The outcome of this investigation was the F. I. D. No. 133, which condemned the use of immature citrus fruit in the following language:

> "There is evidence to show that the consumption of such immature oranges, especially by children, is apt to be attended by serious disturbances of the digestive system."

Acting upon this decision, restrictive measures were adopted both by state and national authorities against the sale of immature citrus fruit, and against any attempt to conceal such immaturity, by sweating or by misbranding or mislabeling, or in any other form which might deceive the public as to the real quality of the fruit involved.

The carrying out of these measures required a standard by which to judge the maturity of the fruit. Such a standard was first set by Florida as the result of the findings of a commission of experts, appointed for the purpose, which reported that an orange could be regarded as mature when "its chemical analysis would show the percentage by weight of the total sugar, as invert sugar, to be seven times, or more, than the weight of the total acid, as citric acid."

This was modified by the National Bureau of Chemistry, to read as follows:

"All mature oranges shall contain not less than eight parts of total solids to one part of total acid, calculated as citric acid without water of cristalization";

And that—

"All mature grapefruit shall contain not less than seven parts of total solids to one part of total acid calculated as citric acid without water of crystalization."

As a result of the restrictive measures above referred to, two cargoes of grapefruit from Porto Rico were destroyed at the port of New York by the health officers in charge in 1916, for not reaching the required ratio of 7. Our growers protested, and sent a commission to Washington, to present their claims before the competent authorities. They were given a hearing by the Bureau of Chemistry in which arguments were presented by the commission to show that the standard set might not be applicable to Porto Rican fruit, that the fruit here might come to maturity before it reached the stated ratio of 7, and that perhaps it might never come up to this ratio after all. The chief claim, however, was that the fruit here was fully matured before the ratio of 7 was reached.

To decide this point, as well as to gather data that might be useful in cultivating, fertilizing, and handling the fruit, the investigation herein reported was started in 1916 by the former chemist, Mr. W. B. Cady.

In 1917 Mr. Cady resigned, and the writer was appointed as his successor. The problem was immediately submitted to his consideration by the then Director of the Station, Mr. W. V. Tower, with the request that the work begun by Mr. Cady be continued. However, Mr. Cady's plan of investigation was never available to the writer, and all that was found in the records was a mass of data from which to judge the purpose that Mr. Cady undoubtedly had in mind. The above statement it not made in any spirit of criticism but simply as a candid expression of facts unavoideable in a report of this nature which must embody data collected by two different investigators, and in which each one must have his due. From the data at hand the conclusion was reached that the chief aim was to find out whether grapefruits matured before reaching a ratio of 7, and to study the effect of sweating, and storing, on the ratio and sugar content of the juice. Besides, there were data to show that an attempt had been made to gain an

insight into the seasonal changes suffered by the fruit, and to correlate these changes with the kind of soil and fertilizers used. These may not have been exactly the aims sought; but in the absence of a definite statement as to the real purpose of the investigation, that is what the data seem to show.

The data left by Mr. Cady, included the following records:

1. Measurements of the size of the fruit, and thickness of skin, weight of the fruit, skin, and juice, and analyses of the juice of samples taken periodically. The analyses of the juice included determinations of solids in solution, sugar as invert, sucrose, and acid as citric acid. Also notes on the color of the skin.

2. Parallel analyses of fruit stored without sweating and after being sweated, on which all the above data were also taken. Besides, the number of fruits going to rot during storage was ascertained in each case.

3. Notes on the types of soils on which each tree stood, and chemical analyses of each soil.

4. Some notes on the fertilizers used, but not enough to be useful in drawing conclusions.

5. Tables constructed with the data obtained to show correlations between the factors compared.

The method followed by Mr. Cady as evidenced from his notes consisted in having one or two trees set aside in each of a number of plantations, so that he could go around periodically, (usually every 15 days from September to February) and pick samples from each of the trees for his various experiments. Notes were taken on the type of soil on which the trees stood, and soil samples taken from around the base of the trees were analyzed. In a number of instances notes about the fertilizer used were taken.

The writer thought that no conclusions as to the effect of fertilizers could be drawn from data collected in this fashion, where there were so many factors of variation involved and decided to drop that phase of the project referring to fertilizers. Each tree was fertilized differently, planted on different soil, and under different climatological conditions.

The effect of sweating and storing fruit was so clearly shown by Mr. Cady's work that the writer did not think it necessary to conduct any more experiments along this line.

The system of having trees set aside in different plantations and of collecting samples periodically was continued, and the soils were analyzed whenever new trees were chosen. It was also decided to

carry out determinations of the content of nutritive ingredients in the whole fruit, to gain a general idea of the amount of fertilizer removed by an average crop of grapefruit under the conditions of cultivation and types of soils that obtain in this country. By what has been said it will be evident that all data collected from 1916–1917 was the work of Mr. Cady.

AIMS.

With these general ideas in mind, the original plan of investigation, whatever it might have been, was reconstructed to cover the following aims. These aims were of course to be attained with the aid of Mr. Cady's data:

1. To determine whether grapefruit may be considered mature before it reaches a ratio of solids to acid of 7.

2. To determine the time of the year when grapefruit reached a ratio of 7, Mr. Cady's work having demonstrated that grapefruit here did come up to this ratio.

3. To find out whether there was any difference among the different varieties cultivated here in regard to the points noted above.

4. To gain some knowledge as to the proportions of fertilizing ingredients present in the fruit at different stages of its maturation period.

5. To determine the influence of rainfall on the composition of the fruit.

6. To find out the influence, if any, of type of soil on any of the points enumerated.

7. To see whether the soil composition bears any relation to the composition of the fruit, or to its quality.

8. To find out the influence of storing and of sweating the fruit on the ratio, appearance, keeping qualities, weight, proportion of skin and juice to weight of fruit, sugar content of juice, and, in general, upon the quality of the fruit as a whole.

An immense amount of work would be required to arrive at definite conclusions on any of the points enumerated above. With the data at hand to date, many of the questions raised may be considered as definitely settled, while others would require further work, and changes in the method of investigation to complement the data obtained. However, as it is not possible to give for the present more time to this project, all data collected, whether leading to definite conclusions or not, will be here published, so that they may be available to any other investigator on the subject who may have

use for them. This should be taken, then, only as a report of a work which has not been carried to completion.

For clearness in the discussion, this report will be presented in two parts. Part I will deal with the changes undergone by the fruit without any reference to the factors affecting them, and will take up the first four points enumerated. Part II will be devoted to a discussion of the factors, natural and otherwise, affecting the changes discussed in Part I.

PLAN OF THE INVESTIGATION.

As already explained, there were two lines of investigation indicated by Mr. Cady's work, which the author discontinued, namely: the effect of fertilizers, and the effect of sweating and storing on the composition and quality of the fruit. The former, because it was not thought possible to arrive at any conclusions with the data obtained, or obtainable under the circumstances,[1] and the second, because the point was deemed sufficiently proven by the data at hand.

For the work to be done trees were selected in different plantations in the fruit district along the northern coast. The plantation owners, of whom a list is given further on, were liberal enough to part with the crop of the tree or trees selected, and from each tree a sample of ten or twelve fruits was picked every fortnight. These samples were brought to the laboratory and not later than twenty-four hours after, subjected to the tests given below.

The trees were so chosen that both clay and sandy soils were represented. For the season 1917 to 1918 trees of both Marsh's Seedless and Duncan were used, but for the following season, 1918 to 1919, only Duncans were selected, as this variety is by far the most generally planted of all. The triumph variety is very little cultivated.

During the season 1917–1918 the following data were taken on the fruit:

(*a*) Weight of fruit.
(*b*) Size of fruit.
(*c*) Thickness of skin.
(*d*) Weight of skin.
(*e*) Weight of juice extracted.
(*f*) Solids in solution in juice.
(*g*) Acidity in juice expressed as anhydrous citric acid.

[1] No plan for fertilizing the trees systematically was available, but only notes on the fertilizers used by the planters themselves on their respective places. These varied in amount, composition and character, and could not, of course, serve as a basis for any conclusion.

No soil analyses were performed during this season, due to lack of time.

During the season of 1918–1919 the sucrose content, invert sugar, and total sugar as invert, were determined in addition to the tests given above. Besides, observations were made on the color of the fruit, consistency of the juice cells, and taste (whether sweet, tart, or sour) of the juice.

Soil samples from around the trees used this year were analyzed.

On the samples picked during this season, determinations of nitrogen, ash, phosphoric acid and potash were made on the whole fruit.

METHODS.

The data left by Mr. Cady were taken as follows:

The seasonal variations were observed on samples picked biweekly from trees set aside for the purpose, as already explained. The data included all those detailed above, except the nitrogen determinations and the ash analyses.

The method of sampling followed is described by Mr. Cady in his notes as follows:

> "Beginning September 22nd, we selected an average Duncan tree in eight different groves, picked twelve fruits from each of these trees at intervals of every two weeks as work at the laboratory would permit. These fruits were brought to the laboratory and analyzed. The groves from which this fruit was taken ranged from a heavy clay to a light sandy soil."

The effect of storing and of sweating was determined by picking 80 fruits from each of five trees every month, dividing these into two lots of 40 each, one lot sweated and the other left in natural condition. Each week 10 fruits of each lot were weighed, measured, as already explained, and analyzed. This is described by Mr. Cady as follows:

> "*Changes that take place in holding sweated and unsweated fruit.*—These tests were from five different groves. Eighty fruits were taken from each grove and divided into lots of 40 each. Forty fruits were sweated forty-eight hours at a temperature of from 90 to 95 degrees Fahr. The other 40 were held in the laboratory for analysis. Ten fruits were analyzed each week from the sweated and unsweated lots."

Another method used consisted in picking lots of 150 or 200 fruits and storing the fruit, one-half sweated and the other unsweated. Samples of 10 fruits were analyzed each succeeding week, and a' other observations noted made on them.

Samples of soils in which these trees stood were analyzed as well. As no description of the methods used in the analysis and measurement of the fruit employed by Mr. Cady are available a brief account of those used by the writer will be given.

METHODS OF ANALYSIS.

Size.—The size of the fruit has been expressed by the figure indicating the number of fruits packed in a standard box. This was determined by passing the fruit through circular holes, and taking the number corresponding to that through which the fruit would pass fitting closely.

The dimensions and the corresponding numbers were as follows:

Diameter of holes in inches.	Corresponding number indicating size of fruit.
3 15/16	80
4 1/16	72
4 1/4	64
4 7/16	54
4 5/8	46
4 7/8	36

The contrivance for taking these measurements was found in the laboratory, so that it may be taken for granted that it was used by Mr. Cady in taking his measurements.

Thickness of rind.—The fruits were cut across midway between the upper and lower ends through a plane perpendicular to the axis of the fruit.

On one of the halves, and at several places around the circumference, a ruler was laid flat on the plane section, passing through the center, and the diameter, including and excluding the rind, taken. One-half the difference between the two diameters was taken as the thickness of the rind at that particular point. The average of five or six thicknesses thus found was taken as the thickness of the skin of that particular fruit. The average of the thicknesses of all the fruits in the sample was taken as the thickness of rind in the sample.

Proportion of rind and juice.—The per cent rind and juice were found as described under juice analysis.

METHOD OF ANALYSIS.

Juice analysis.—The fruits were peeled, the peeled fruit expressed by hand, and the pulp strained through cheese cloth until

practically all of the juice had been extracted. This operation was always performed by the same person. The fruits were weighed before peeling and expressing, so that by weighing the skins and the juice the proportion of each in the whole fruit was easily calculated. The seeds were then separated from the juice, and the latter submited to the following tests:

Total solids.—A tall cylinder was filled to the brim with the juice, the air bubbles allowed to escape, and a Brix spindle inserted. The temperature was taken, the Brix spindle read, and the reading corrected according to the temperature by means of Spencer's table of corrections, The corrected degree Brix was taken as the per cent solids in solution. From the degree Brix the specific gravity was found in a table of equivalents.

Acidity.—Ten cubic centimeters were measured off by means of a pipette into 150 cc. Erlenmeyer flask, 50 cc. distilled water added, and the whole boiled to expel carbon dioxide. The diluted juice was cooled, phenolphthalein added as indicator, and titrated with caustic soda solution so prepared that one cubic centimeter was equivalent to one-hundredth gram of anhydrous citric acid.

Sucrose.—The double polarization method of Clerget was used. The inversion was accomplished by concentrated hydrochloric acid, acting on the juice at ordinary temperatures for twenty-four hours. Hertzfeld formula and table of corrections for the constant were employed in the calculations.

Invert sugar.—School de Hans Method was used.

Total sugar as invert.—This was calculated from the figures for sucrose and invert sugar.

DETERMINATION OF FERTILIZING INGREDIENTS IN WHOLE FRUIT.

Preparation of the samples.—For this work the whole fruit was quartered, an upper and a lower quarter were peeled and squeezed for the tests already explained and the other two quarters were passed without peeling or pressing through a chopping machine. The fruit was thus converted into a pulp containing skin, juice, seeds, and all. The whole was then weighed, and dried at 80° to 100° C., in a large air oven, and the loss in weight determined. The drying process was continued until the dried residue could be easily ground in a mill to a coarse powder. The powder thus obtained, which resembled ground roasted coffee, was preserved in wide-mouthed glass jars tightly closed. In the samples so prepared, the following determinations were made:

DETERMINATIONS.

Nitrogen.—Nitrogen was determined by the regular Kjeldahl process in 10-gram samples.

Phosphoric anhydride was determined in the ash, by dissolving in agua regia, and following the volumetric method outlined in bulletin 107 of the Bureau of Chemistry, U. S. Department of Agriculture.

Potash.—Potash was determined in the ash according to the following method: A portion of ash corresponding to 5 grams of sample prepared as described above was boiled for one-half hour with 100 cc. to 150 cc. distilled water. The solution obtained was made alkaline with ammonia and treated with ammonium oxalate, without filtering. The solution was made to a volume of 200 cc. passed through a dry filter, and an aliquot of the filtrate taken. The aliquot was evaporated to dryness after the addition of 1:1 sulphuric acid, the residue burned to destroy organic matter and expel ammonia, the white residue taken up with water, and the solution treated with barium chloride to remove sulphates. The precipitate was filtered off, and washed. The filtrate and washings were received in a silica dish, treated with perchloric acid, and evaporated on the water bath until white fumes were given off. The residue was then taken up with 95 per cent alcohol, thoroughly washed with alcohol by decantation, passed through a Gooch crucible, washed again in the crucible, dried at 120–130° C. and weighed. Hot water was passed through the crucible, and then 95 per cent alcohol, the crucible dried once more at 120–130° C., and then weighed again. The difference between the first and second weighings represents the potash as potassium perchlorate. By multiplying the weight of the potassium perchlorate obtained by 0.340, the actual potash was obtained.[1]

Ash.—The ash was obtained by burning the material to whiteness in a muffle furnace, well regulated to avoid loss of alkalis by volatilization.

Moisture.—The moisture in the prepared sample was determined by heating in a flat German-silver dish, to constant weight in an oven at 110° C.

Taking into account the moisture content of the prepared sample and the loss in weight sustained by the sample during the process

[1] This method was followed because it was very hard at the time to secure chloroplatinic acid, which would have been preferred as a precipitant by the writer.

of preparation, the results obtained were calculated back to the whole fruit.

ARRANGEMENT OF DATA.

The data will be presented mostly in tabular form, with occasional graphs based on the tables given. The discussion will be by subjects, taking up each of the points to be proven in succession, and grouping together all the data necessary to make clear the point under discussion. In grouping the data appertaining to each subject, however, they will be presented, as far as possible by seasons. The method of averages has been freely used, but all figures for individual cases are also given, so that the degree of variation may be better appreciated.

PART I.

NATURAL CHANGES.

By the study of these changes, an effort will be made to determine the following points:

1. Whether grapefruit may be considered matured before the ratio of total solids to acids in solution in its juice reaches 7.

2. What is the time of the year when grapefruit reaches the aforesaid ratio of 7 under our conditions.

3. To find out whether there is any difference among the varieties cultivated in this country in regard to the points noted above.

4. To gain some knowledge as to the proportions of fertilizing ingredients present in the fruit at different stages of its maturation period.

SEASONAL CHANGES OF GRAPEFRUIT.

In order to obtain the necessary knowledge to settle the four points at issue in this phase of the investigation, it was found necessary to find out first of all what changes were undergone by the fruit when left on the tree under natural conditions throughout the harvesting season; hence, the biweekly analyses of samples picked from trees selected in different localities representative of the fruit district of the Island. In this study the three varieties of grapefruit almost exclusively planted in this country received separate attention so as to be able to make comparisons between their respective behaviors. The three varieties referred to are the "Triumph" the "Marsh's Seedless" and the "Duncan". Of all, the Duncan is the most popular, followed by the Marsh's Seedless, while the "Triumph" is very little planted.

This work was continued uninterruptedly from September, 1916, to February, 1919; that is, through three consecutive seasons. During the first season, 1916 to 1917 (work conducted by Mr. Cady), the three varieties were studied; during the next season, 1917 to 1918, only the "Marsh's Seedless" and the "Duncan" received attention, the writer being convinced that no more data were neces-

sary to judge the "Triumph," while during the last season, 1918 to 1919, only the "Duncan" variety was used, as enough data were already on hand about the "Marsh's Seedless," and enough information had been accumulated for the purposes of a comparison. Besides, the Duncan being planted almost universally, was chosen exclusively for the tests of this year, to simplify matters.

The results of the analyses, by seasons, varieties, and trees, are given below in tabular form, for each season and each variety separately, with proper comments in each case. Upon the facts thus revealed, conclusions as regards the points enumerated will be drawn in a further discussion of the data.

SEASON 1916 TO 1917.

Trees were selected in different groves, and every fortnight 10 to 12 fruits were picked from each one of the selected trees. The samples so picked were all analyzed in the same day and by the same methods. These trees were set aside by the owners of the groves, and no fruits, except the samples, were picked from them. This gave the investigator the chance to choose his fruits to suit his ideas. In this instance the fruits were chosen so that they would be, as far as possible, from the same bloom.

Following will be found a list of the groves in which trees were selected for the biweekly analyses above referred to, and analyses of the soils on which they stood.

The discussion as to the relations which exist, if any, between kind of soil and composition or behavior of fruit, will be deferred for the present, to the time when this phase of the problem comes under consideration.

Trees Selected for the 1916-17 Work.

Grove	Location of grove	Owner or Manager	Tree (Variety)
A	Pueblo Viejo	Mr. Boyd	Duncan Triumph
B	Vega Baja	Mr M. L. David	Duncan Marsh's Seedless
D	Pueblo Viejo	Mr. Dunham	Duncan
E	Palo Seco	Mr. Fletcher	Duncan
G	Trujillo Alto	Mr. Lippit	Duncan
I	Bayamón	Mr. Newton	Duncan
J	Bayamón	Mr. Parkhurst	Duncan
K	Pueblo Viejo	Mr. Reed	Triumph
L	Rio Piedras	Mr. Scoville	Marsh's Seedless
N	Vega Alta	Mr. E. D. Stevens	Duncan

COMPOSITION OF SOIL IN WHICH EACH TREE STOOD.

Soil samples were taken from around the base of each tree, and analyzed with the following results:

Soil taken from near test grapefruit tree in Grove A, March 1917. "Sandy Loam."

Reaction	Acid.	
Insoluble matter	85.66	per cent.
Iron and alumina	9.70	per cent.
Lime	0.05	per cent.
Magnesia	None.	
Phosphoric acid	0.13	per cent.
Potash	0.100	per cent.
Nitrogen	0.050	per cent.

Soil taken from near test tree "Duncan" in Grove B, near Vega Baja, March 7, 1917. Red clay loam.

Reaction	Acid.	
Insoluble matter	77.45	per cent.
Iron and alumina	13.40	per cent.
Lime	0.35	per cent.
Magnesia	Trace.	
Phosphoric acid	0.191	per cent.
Potash	0.009	per cent.
Nitrogen	0.130	per cent.

Soil taken from near test tree "Marsh's Seedless" in Grove B. Red Sandy Clay.

Reaction	Acid.	
Insoluble matter	81.80	per cent.
Iron and alumina	11.50	per cent.
Lime	0.30	per cent.
Magnesia	Trace.	
Phosphoric acid	0.191	per cent.
Potash	0.0097	per cent.
Nitrogen	0.101	per cent.

Soil taken from near test grapefruit tree in Grove I. "Sandy loam."

Reaction	Acid.	
Insoluble residue	88.21	per cent.
Iron and alumina	5.70	per cent.
Lime	0.20	per cent.
Magnesia	None.	
Phosphoric acid	0.191	per cent.
Potash	0.039	per cent.
Nitrogen	0.112	per cent.

Soil taken from near test tree in Grove E, March 26, 1917.

Reaction	Acid.	
Insoluble matter	72.51	per cent.
Iron and alumina	12.40	per cent.
Lime	6.40	per cent.
Magnesia	0.47	per cent.
Phosphoric acid	0.606	per cent.
Potash	0.097	per cent.
Nitrogen	0.168	per cent.

Soil taken from near test tree in Grove G, March 18, 1917. Clay soil "very hard."

Reaction	Acid.	
Insoluble residue	62.60	per cent.
Iron and alumina	19.92	per cent.
Lime	0.15	per cent.
Magnesia	Trace.	
Phosphoric acid	0.331	per cent.
Potash	0.174	per cent.
Nitrogen	0.168	per cent.

Soil taken from near test tree in Grove I, near Bayamón, February 9, 1917. "Sandy loam."

Reaction	Acid.	
Insoluble matter	87.49	per cent.
Iron and alumina	6.70	per cent.
Lime	0.10	per cent.
Magnesia	Trace.	
Phosphoric acid	0.35	per cent.
Potash	0.019	per cent.
Nitrogen	0.121	per cent.

Soil taken from near test grapefruit tree in Grove J, near Bayamón, March 7, 1917. "Sandy soil."

Reaction	Acid.	
Inslouble matter	90.08	per cent.
Iron and alumina	5.70	per cent.
Lime	0.14	per cent.
Magnesia	None.	
Phosphoric acid	0.191	per cent.
Potash	None.	
Nitrogen	0.214	per cent.

Soil taken from near annual test tree "Triumph," Grove K, "Reddish clay soil." March 20, 1917.

Reaction	Acid.
Insoluble residue	65.40 per cent.
Iron and alumina	19.50 per cent.
Lime	0.20 per cent.
Magnesia	None.
Phosphoric acid	0.191 per cent.
Potash	Trace.
Nitrogen	0.168 per cent.

Soil taken from near test tree in Grove L, March 26, 1917. "Sandy Loam."

Reaction	Acid.
Insoluble residue	87.11 per cent.
Iron and alumina	8.40 per cent.
Lime	0.20 per cent.
Magnesia	None.
Phosphoric acid	0.191 per cent.
Potash	None.
Nitrogen	0.112 per cent.

Soil taken from near test grapefruit tree in Grove N, March 7, 1917.

Insoluble residue	87.94 per cent.
Iron and alumina	6.40 per cent.
Lime	0.30 per cent.
Magnesia	Trace.
Phosphoric acid	0.100 per cent.
Nitrogen	0.097 per cent.
Potash	0.089 per cent.

The analyses of the different samples of fruit are presented below in tabular form for each tree and for each variety.

INDIVIDUAL TREE RECORDS, SEASON 1916–1917.

TABLE 1.

Analyses of Fruit (Duncan) from Test Tree, Grove A, Pueblo Viejo.

Date picked	Average weight	Average size	Color	Thickness of skin in inches	Per cent skin	Weight of fruit per box	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio invert sugar to sucrose
October 3	583	36	G. Y. T	3/8	31 31	20.988	37.68	8 2	1.28	6 4	2.44	4.89	2.33	1.047
October 6	575	46	G. Y. T.	5/16	30.56	26 450	38 50	7.8	1.39	5.5	2.44	4.65	2.09	1.167
October 28	592	54	G. Y. T.	5/16	31 74	31.968	38 87	8.0	1 29	6.3	2.69	4.40	1.59	1.691
November 3	505	54	G. Y. T.	9/32	26.41	27.270	43 80	8.6	1.25	6.9	3.10	4.16	94	3.297
November 21	490	54	Y. S. G. T.	9/32	25.61	26 460	46.65	8.1	1.34	6 0	3.10	4.89	1.67	1.856
December 11	617	46	Y. G.	3/8	29.83	28.382	41.83	8 2	1.20	6.9	2.69	4.40	1.59	1.691
February 15	541	40	B. Y.	1/4	30 00	21 640	49.92	8.5	1.25	6.8	3.50	4 89	1.27	2.755
February 22	500	54	Y. S. G. T.	1/4	26.66	27.000	53.21	7.0	1.01	6.9	2.93	4.40	1.35	2.170
Averages for the season	550.3	47		10/32	29.01	26 269.7	43.76	8.05	1.247	6.455	2.86	4.54	1.60	1.787

TABLE 2.

Analyses of Fruit (Duncan) from Test Trees, Grove B, Vega Baja.

Date picked	Average weight	Average size	Color	Thickness of skin in inches	Per cent skin	Weight of fruit per box	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio in vert sugar to sucrose
October 6	379	64	Y. G. T.	1/4	24 78	24 216	43.64	8.5	1.38	6.1	2.98	5.14	2.09	1.401
November 3	317	64	G. S. Y. T.	1/4	25 66	20 288	44 59	9.5	1.52	6.2	2.19	5.38	3.07	0.713
December 29	406	64	Y. G.	1/4	28.57	26.112	50.00	8 0	1.13	7.1	3.10	5.14	1.92	1.614
January 18	466	64	Y. G. T.	5/16	29.46	29.824	47 82	7 7	1.10	7.0	3.50	5.87	2.26	1.555
February 12	684	36	Y. G. T.	1/4	27.03	24.624	42 66	8.6	1.13	7.6	3.67	6.60	2.81	1.306
Averages for the season	450 8	58		8/32	27 10	25 028	45.74	8.46	1.252	6.757	3.06	5.217	2.08	1.517

NOTE.—In working with the fruit a system of noting the comparative amounts of coloring was devised In the charts letters are used to represent these as follows: G., green; Y., yellow; T, tinge; S., slight; Q, quite. Various combinations are employed.

TABLE 3.

Analyses of Fruit (Duncan) from Test Tree, Grove D, Pueblo Viejo.

Date picked	Average weight	Average size	Color	Thickness of skin in inches	Per cent skin	Weight of fruit per box	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio invert sugar to sucrose
September 22	560	54	Y. G.	5/16	28.80	30,240	41.03	7.8	1.35	6.2	2.69	5.38	2.57	1.046
October 20	585	54	Y. S. G. T.....	3/8	30.84	28,890	42.98	8.6	1.26	6.9	3.50	5.14	1.52	2.302
December 8	588	54	Y. G.	5/16	28.57	29,052	42.85	8.9	1.21	7.3	2.69	5.63	2.82	0.953
January 18	545	54	Y. S. G. T.....	1/4	29.53	29,430	44.36	8.9	1.25	7.1	2.69	5.14	2.33	1.154
Averages for the season......	544.5	54		10/32	29.43	29,403	42.79	8.55	1.24	6.895	2.89	5.32	2.31	1.351

TABLE 4.

Analyses of Fruit (Duncan) from Test Tree, Grove E, Palo Seco.

Date picked	Average weight	Average size	Color	Thickness of skin in inches	Per cent skin	Weight of fruit per box	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio invert to sucrose
September 28	550	54	G. Y. T...	5/16	25.58	29.700	29.49	9.3	1.59	5.8	3.10	5.87	2.65	1.169
November 8	655	50	G. Y. T.........	11/32	25.73	33.750	37.68	8.8	1.16	7.6	3.50	6.36	2.74	1.277
December 2	701	46	G. Y. T.........	1/4	22.99	33.346	41.00	9.1	1.10	8.3	3.10	6.11	2.89	1.072
January 22	483	64	G. Y. T.........	1/4	28.50	30.912	47.35	9.3	1.23	7.5	3.67	5.63	1.84	1.994
Averages for the season......	599.7	54		9/32	25.67	31.402	38.88	9.12	1.27	7.181	3.34	5.87	2.53	1.320

TABLE 5.

Analyses of Fruit (Duncan) from Test Tree, Grove G, Trujillo Alto.

Date picked	Average weight	Average size	Color	Thickness of skin in inches	Per cent skin	Weight of fruit per box	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio invert to sucrose
September 28	600	46	G. Y. T.........	9/32	21.08	27,600	38.45	8.8	1.39	6.3	2.98	5.68	2.58	1.155
[illegible]ber 6	450	60	G. Y. T.........	1/4	26.28	27,000	45.08	9.5	1.26	7.5	3.67	5.87	2.08	1.764
[illegible]r 7	498	54	G. Y.	5/16	30.64	26,892	44.70	9 2	1.27	7.2	3.50	5.63	2.01	1.741
J[illegible] 24	530	54	G. Y. T.........	1/4	31.13	28,620	40.31	10.0	1.03	9 7	4.16	6.60	2.42	1.719
[illegible] for the season......	519.5	54		9/32	27.27	27,528	42.26	9.37	1.237	7.578	3.565	5.958	2.27	1.570

TABLE 6.

Analyses of Fruit (Duncan) from Test Tree, Grove I, Bayamón.

Date picked	Average weight	Average size	Color	Thickness of skin in inches	Per cent skin	Weight of fruit per box	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio invert sugar to sucrose
September 25	550	56	G. Y. T.	5/16	25.58	30,800	41.34	8.8	1.29	6.8	3.10	5.38	2.16	1.435
October 9	625	46	G. Y. T.	5/16	29.17	28,750	38.72	8.6	1.29	6.7	2.69	4.89	2.08	1.2[illegible]
October 23	637	46	G. Y. T.	9/32	28.87	29,802	43.47	8.6	1.19	7.2	2.69	5.35	2.57	1.046
November 8	643	46	G. S. Y. T.....	9/32	27.27	29,578	42.38	8.6	1.14	7.5	2.69	5.14	2.33	1.154
November 21	561	54	G. S. Y. T......	5/16	27.38	29,754	41.32	8 6	1.10	7.8	2.69	5.36	2.57	1.046
December 8	810	36	G. Y.	7/16	31.07	29,100	42.70	8.5	1.05	8.1	2.98	4.89	1.84	1.[illegible]
December 29	718	36	Y. G. T.		28.14	25,668	42.36	8.5	1.00	8.5	2.98	5.63	2.58	1.1[illegible]
January 18	658	46	Y. S. G. T......	9/32	26.58	30,268	42.96	8.7	1.10	7 9	3.50	5.36	1.76	1.[illegible]
February 9	725	36	Y. S. G. T......		27.90	26,100	42.57	8 6	1.00	8.6	3.67	5.67	2.08	1.765
March 9	658	46	Y. S. G. T......	5/8	24.05	30,268	48.10	8.9	1.08	8.2	....	....	....	....
Averages for the season......	657	45		10/32	27.59	28,9648	42.51	8.64	1.124	7.686	2.987	5.32	2.212	1.346

TABLE 7.

Analyses of Fruit (Duncan) from Test Tree, Grove J, Bayamón.

Date picked	Average weight	Average size	Color	Thickness of skin in inches	Per cent skin	Weight of fruit per box	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio invert sugar to sucrose
September 22	568	46	G. S. Y. T.	3/8	28.38	27,048	40.53	8.4	1.51	5.6	3.08	4.89	1.74	1.741
October 6	583	46	G. Y. T.	3/8	30.80	26,818	38.84	8.9	1.49	6.0	3.10	5.38	2.16	1.435
October 23	579	46	G. S. Y. T.	11/32	27.26	26,634	44.89	9.1	1.33	6.8	3.10	6.11	2.86	1.072
November 3	583	46	G. S. Y. T.	11/32	29.14	26,818	43.40	8.6	1.27	6.8	2.69	4.89	2.08	1.298
November 21	551	54	G. S. Y. T.	5/16	27.83	29,754	43.63	8.4	1.17	7.2	2.69	4.89	2.08	1.298
December 8	650	46	G. Y.	3/8	29.33	29,900	42.66	9.0	1.22	7.4	3.10	5.63	2.41	1.286
December 29	563	54	Y. G.	5/16	27.86	31,482	44.29	9.0	1.20	7.5	3.50	5.38	1.76	1.988
January 18	633	46	Y. G. G. T.	1/4	29.05	29,118	40.54	9.2	1.36	6.7	3.50	5.38	1.76	1.988
February 9	533	50	Y. G. T.	....	28.81	26,650	43.44	9.0	1.20	7.5	3.67	6.11	2.32	1.581
March 9	558	46	Y. G. T.	....	28.58	25,668	46.11	9.5	1.40	6.7	3.91	6.11	2.08	1.879
Averages for the season	584.1	48		11/32	28.66	27.996	43.33	8.91	1.315	6.775	3.28	5.47	2.128	1.517

TABLE 8.

Analyses of Fruit (Duncan) from Test Tree, Grove N, Vega Alta.

Date picked	Average weight	Average size	Color	Thickness of skin in inches	Per cent skin	Weight of fruit per box	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar invert	Cane sugar	Ratio invert to sucrose
September 25	566	46	G. Y. T.	1/4	26.13	26,036	43.92	8.2	1.28	6.4	3.08	5.14	1.94	1.567
October 5	516	64	Y. G.	9/32	29.41	33,024	38.08	8.7	1.24	7.0	2.69	5.68	2.82	0.953
October 23	525	54	G. Y. T.	9/32	27.09	28,350	42 98	8.9	1.27	7.0	3.50	5.38	1.76	1.988
November 3	375	64	G. S. Y. T	8/32	28.11	24,000	39 57	8.6	1.07	8.0	2.44	5.14	2.58	0.930
November 21	400	80	G. S Y. T	7/32	22.97	32,000	40.04	9.6	1.43	6.7	3.10	6.11	2.89	1.072
December 8	450	64	G. Y. T.	3/8	37 50	28,800	45 37	7.5	1.00	7.5	2.98	4.40	1.35	2.170
December 29	541	64	Y. G.	....	24.61	34,624	46.15	9 0	1.15	7.8	3.50	5.38	1.76	1.988
January 18	400	63	Y. G. T.	1/4	28.12	25,200	46.12	8.5	.91	9.3	3.50	6.36	2.74	1.277
Averages for the season	471.6	62		8/32	27.99	29,008	42.77	8.62	1.166	7.392	3.092	5.433	2.28	1.306

From the above tables of individual tree records the averages of all samples picked on the same date were found, and tabulated as shown below:

TABLE 9.

Showing the Mean Composition of Fruits Sampled from Eight Different Groves on Specified Succeeding Dates.

Date picked	Average Weight	Per cent skin	Per cent juice	Solids in juice	Citric acid	Ratio of solids to acid	Invert sugar	Total sugar	Cane sugar	Ratio of invert sugar to cane sugar
September 25 ..	611.5	28 06	39.42	8.4	1.36	6.2	2.93	5.11	2.18	1.36
October 6	584	29 65	43.78	8 5	1.36	5.1	2.84	5.24	2.28	1.24
October 24	617	28 60	43.48	8.5	1 20	6.8	3.05	5.35	2.17	1 40
November 3 ...	583	27 49	43.39	8 7	1.12	7.2	2 95	4.78	2.17	1.36
November 21 . .	582	26.27	45.15	8.6	1.19	7.3	3.29	5.40	1.99	2 06
December 8....	596	29 96	42.88	9.2	1.14	7.5	3 10	5.35	2 12	1.46
December 29....	665	27.58	44.30	8 9	1.11	8 0	3.38	5.62	2.11	1.60
January 22	580	28.39	45.18	8 8	1.15	7.6	2 78	5 41	1.80	1.54
Averages for the season	602.31	28.25	43 57	8.7	1.205	7.28	3.045	5.258	2.102	1.418

The averages representing the mean composition of the fruit for each individual tree for the season, have been grouped together as shown in the following:

TABLE 10.

Showing Mean Composition of Fruit for Each Tree for the Season.

DUNCAN FRUIT (1916–1917).

Grove	Average weight in grams	Average size	Thickness of skin in inches	Per cent skin	Weight of fruit per box in grams	Per cent juice	Solids in juice	Acid (citric) (anhydrous)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio of invert sugar to sucrose
A	550.3	47	5/16	29.01	26,269.7	43.76	8.05	1.247	6.455	2.86	4.54	1.60	1.047
B	450.8	58	1/4	27.10	25,020.8	44.74	8.46	1.252	6.757	3.06	5.217	2.08	1.517
D	544.5	54	5/16	29.43	29,483	42.79	8.55	1.240	6.895	2.89	5.82	2.81	1.251
E	599.7	54	9/32	25.67	31,402	38.88	9.12	1.270	7.181	3.34	5.87	2.53	1.320
G	519.5	54	9/32	27.27	27,528	42.26	9.37	1.237	7.578	3.565	5.953	2.27	1.570
F	657.	45	5/16	27.59	28,964.8	42.51	8.64	1.124	7.686	2.967	5.320	2.218	1.346
J	584.1	48	11/32	28.66	27,996	43.33	8.91	1.315	6.775	3.28	5.47	2.128	1.517
N	471.6	62	1/4	27.99	29,006	42.77	8.62	1.166	7.392	3.092	5.488	2.23	1.386

DISCUSSION OF RESULTS.

A discussion of the figures presented, now follows. The discussion will be by topics and very brief, with the sole purpose of bringing out the salient facts as revealed by this set of tables. Each set of tables for the different varieties and seasons will be successively taken up in the same fashion, and after each set has been discussed separately, a general discussion, establishing the proper relations will be given.

For convenience in the discussion the individual trees will be referred to in this particular instance by the letter designating the grove where they were located.

DUNCAN, 1916–1917

Size.—See tables. Out of 53 samples picked and measured, seventeen gave an average size of 46, fifteen sized 54, nine were 64's and five were 36's. The rest were distributed one apiece between sizes ranging from 80 to 40. As seen, the sizes ranged mainly between 36's and 64's, the most common being 46 and 54.

The size of the fruit was not affected in any fixed manner by the date of picking, within the limits of time set forth in the tables.

Weight.—The average weight per fruit fluctuated, naturally, as the sizes, although it differed even for fruits of the same size. Contrary to expectations, higher averages of weights per fruit were associated with lower contents of juice for the same size of fruit. Take, for instance, the samples of the trees on grove A, picked on October 23, November 3, and November 21, all of size 54. Their percentage of juice increased in the order mentioned, while the average weight per fruit decreased in the same order, there being a difference of 102 grams per fruit between the first and last, in favor of the first. Again in the samples picked from tree B on October 6, November 3, December 29 and January 18, all of average size 64, it may be noticed that the second sample, with a higher juice content than the first, shows a smaller weight per fruit, while the fourth sample, with a lower juice content than the third, shows a higher weight per fruit. This in spite of the fact that the solids in juice are higher in the second sample than in the first and lower in the fourth sample than in the third.

In the samples picked from tree D, all of size 54, the first sample, with the lowest juice content of all, shows the highest weight per fruit while the last with the highest juice content of all shows much lower weight per fruit than the first. The second and third samples,

with about the same juice content, exhibit very nearly the same weight per fruit; still, the slight difference there is, is in favor of the fruit with the lower juice content. In the last two samples, size 54 of tree G; in the second, third, and fourth samples of tree I, size 46; in the first four samples of tree J, size 46; and in fact, in practically every instance where fruit from the same tree and of the same size are compared, the same relation exists.

It seems, then, that the weight per fruit changes in a direction opposite to the juice content, independent of the solids in solution and of the ratio. Turning now to the tables of averages (see tables 9 and 10) we find the same relations to exist in a general way.

Taking the weight of fruit per box, to obviate the differences due to sizes, we find again that no definite tendency can be detected.

Per cent juice.—The general trend of the changes in juice content is toward an increase as the season advances. In some cases there may be a little fluctuation, but there is always a perceptible tendency to increase, while in many instances the increase is shown without interruption. This may be seen from an examination of both the individual tree records and the tables of averages. (See tables No. 1–10.)

In tree A, except for a slight break in the sixth sample, the figures show an uninterrupted chain of increases, and even the sample just excepted shows a higher juice content than any of the first three. The last sample is the highest in juice, and contains 15.33 per cent more than the first, which is the lowest. The average juice content of all the samples contains 6.08 per cent more juice than the first sample.

There is some fluctuation shown by tree B, but the general trend is upward, as shown by the fact that the average of all the samples comes up higher than the first by 2.10 per cent.

Tree D shows a practically continuous increase. The same is true of tree E. Trees G, I, and J show fluctuations but in every instance the average is higher than the content of the first sample.

It is only in tree N that the tendency to increase is not clearly shown; however, the last three samples in this tree are higher each than any of the preceeding ones.

The table of averages shows the tendency of the per cent juice to increase very plainly. All percentages are higher than the first, and the average of the last four figures is higher than the average of the three figures immediately preceeding them, which follow the

first in succession. Besides, the average of all figures is higher than the first by 4.15 per cent.

It may be stated, then, that the per cent juice increases as the season advances.

The average for all of the trees for the whole season was 43.57 per cent. (See table 9.)

Per cent skin.—No regularity can be detected in the variations of this facter. However, there is a slight tendency to increase as shown by the averages of the different trees. The table of averages (No. 9), on the other hand, shows this item to be rather constant throughout the season.

Thickness of skin.—The thickness of the skin fluctuates between somewhat narrow limits. The average for each individual tree is usually equal to the thickness shown by the first sample, or slightly less. In general, then, it may be said that the thickness is rather constant, tending to a very slight diminution as the season advances

Per cent solids in juice.—Out of the eight trees tested the averages for the season were less than the first figure in three instances, greater in three other instances and in the remaining 2 samples it was equal. This makes the solids practically constant. However, in the table of averages of all trees for the season a slight tendency to increase is manifested both in the figures given for the succeeding dates and in the total averages (see table 9).

From the table of averages it may be seen that the lowest average for any date was 8.4 per cent, the highest 9.2 per cent, and the total average 8.7 per cent.

Per cent acid.—The per cent acid diminishes very perceptibly as the season advances. In every tree considered the average for the season for the tree is lower than the content shown by the first sample analyzed. Not only this, but with very few exceptions all the figures following are lower than the first. In the table of averages there is a continued, uninterrupted falling down in the percentage of acid, the only exception being the very last figure which is slightly higher than the two previous ones. The average of all the figures given for the different dates is also lower than the first. ***There is no question, then, that the percentage of acid decreases as the season advances.*** This shows that as Collison[1] found out in Florida, most of the acid, if not all, is formed at the beginning of the season.

Ratio of solids to acid.—As it was to be expected from what has been said in connection with *total solids* and *per cent acid,* this ratio

increases very perceptibly all through the season. Only in case of tree A are some fluctuations noticed, and even here the general tone is upward as shown by the fact that of the seven figures following the first, four are higher than the first, as is also the average for the season. In all the other trees, all figures after the first are higher than the first, and of course the average ratio for each tree for the season is higher than the ratio shown by the first sample.

There is no question, then, that the ratio of solids to acid increases as the season advances.

Of the eight trees tested, four made an average ratio of more than 7 for the season (see table 10). Of those that did not average 7 for their ratio, 3 came within less than 0.3 of making it. Tree A, which averaged only 6.455, never showed a ratio of 7, although it came up to 6.9 on November 21. Of the 7 remaining, two showed a ratio of 7 in October, 3 in November and 2 in December.

Color.—If we notice now the color of the fruit in connection with the ratio we will find—

1. That there were 10 samples marked "G. Y. T." (green, yellow tinge) which ranged in ratio from 5.6 to 9.7, and showed an average ratio of 6.96.

2. There were 8 samples marked "G. S. Y. T." (green, slight yellow tinge). These samples ranged in ratio from 6.2 to 8.0, and their average ratio was 7.12.

3. Three samples were marked "G. Y." (greenish yellow). The ratio for these samples ranged from 7.2 to 8.1 and came up to an average of 7.56.

4. Seven samples were marked "Y. G." (yellowish green) and ranged from 6.2 to 7.8 in ratio. Their average ratio was 7.11.

5. Seven samples were marked "Y. G. T." (yellow, green tinge) and ranged in ratio from 6.1 to 9.3, and showed an average ratio of 7.53.

6. Seven samples whose color was determined as "Y. S. G. T." (yellow, slight green tinge) showed a minimum ratio of 6.0, and a maximum of 8.6. The average ratio for this group of samples was 7.37.

If the color of the fruit is to be taken as a prominent factor in determining the ripeness of grapefruit, then certainly the fruit here reported reached a ratio of 7 before they were perfectly ripe. Only

the first lot of samples noted, marked "G. Y. T." (green yellow tinge), fell below the ratio of 7 in average, and even in this case the average shown, 6.95, is practically 7, and may be considered as 7 for all practical purposes. In this same lot of samples ratios larger than 7, going as high as 9.7, were obtained in individual samples. In all the other cases, in none of which was the fruit perfectly yellow, and in most of which the green predominated, the average ratio was greater than 7, and ratios above 8 were reached in many instances.

Per cent sugar.—Within the limits of the ratios exhibited by the samples examined, the total sugars remained practically constant, with perhaps, a very slight tendency to increase. Thus, out of the eight trees tested, the averages for the season for three of the trees (see table 10) were lower than the per cent shown by the first sample analyzed, 4 trees showed averages higher than the per cent found in the first analysis, and in one tree the two figures coincided. The minimum average found was 4.54 per cent total sugars, for tree A, in which the ratio never reached 7. The highest average was 5.933 per cent total sugars for tree G, in which the average ratio was 7.58. If we arrange the average ratios for the season for the different trees in ascending order, and opposite them write the per cent of total sugars, the fact will be revealed that the total sugars increase in a general way with the ratio, although the variation is not a regular one.

Tree	Ratio	Total sugars
A	6.450	4.54 per cent
B	6.757	5.21 per cent
J	6.775	5.47 per cent
D	6.895	5.82 per cent
E	7.180	5.87 per cent
N	7.390	5.438 per cent
G	7.578	5.968 per cent
I	7.686	5.820 per cent

However, it may be noticed that the increase is continuous until a ratio approaching 7 is reached, when the fluctuations begin. This shows that the differences noticed among the various samples having a ratio of 7 (more or less) are due to individual tree variations, and that the formation of sugar ceases or proceeds at a very slow rate when this ratio is reached. This is a very strong point in favor of the assumption that this fruit is mature when it reaches a ratio of 7, and not before.

The table of averages bears out all of the above statements. Turning now to invert sugar and sucrose, and taking the average for each tree for the season (see table 10). Let us arrange the ratios of solids to acid again in ascending order, and opposite each ratio write their corresponding percentages of invert sugar and sucrose thus:

Ratio solids to acid	Invert sugar	Sucrose	Ratio invert sugar to sucrose
6.45	2.86	1.60	1.787
6.76	3.08	2.03	1.517
6.77	3.28	2.18	1.517
6.89	2.89	2.31	1.251
7.18	3.34	2.53	1.320
7.39	3.09	2.23	1.386
7.57	3.56	2.27	1.570
7.68	2.98	2.21	1.340

It may be noticed that the sucrose increases steadily until the ratio 7.18 is reached, and henceforth it decreases. The invert sugar increases almost continuously, except for only one break, in the fourth figure from the top of the column; however, all figures after the first are higher than the first. Moreover, the average of the last three figures for invert sugar, 3.21 per cent, is higher than the average for the first five figures, 3.08 per cent. This tends to show that the sucrose increases until a ratio of 7, more or less, is reached, while the invert sugar increases continuously. Coupling these facts with the observation previously noted, that the total sugars increase until a ratio of 7 is reached, the conclusion may be drawn that after a ratio of 7 obtains, inversion of the sucrose and decomposition of invert sugar begin. This is again a very strong argument in favor of considering a ratio of 7 as indicating maturity of the fruit.

Summarizing the above comments, we have that the Duncan grapefruit analyzed from September, 1916, to February, 1917, showed the following characteristics:

1. The size of the fruit was very near 54.

2. Their average weight varied between 450.8 and 659.0, the average for the season being 602.31 grams per fruit. The weight showed slight and irregular gains, especially if the weight per box is considered. The unexpected observation was made that among fruits of the same size, those with a lower percentage of juice exhibited more weight per fruit than those containing more juice.

3. There were not great variations in the juice content among the different trees, all fluctuating between 42.26 per cent and 45.74 per cent, with the exception of one tree, which had only 38.88 per cent. The juice increased, but to a very small extent, the range among the averages for different dates being 39.42 per cent to 45.15 per cent, the average for all the trees for the season (see table 9) being 43.57 per cent.

4. The solids contained in solution by the juice ranged among the trees compared between 8.05 and 9.37. The solids were practically constant for a given tree, with a very slight increase as the season advanced. The average for the whole season, for all the trees, was 8.7 per cent.

5. The acid decreased steadily and visibly all along the season, the range being from 1.36 to 1.15 (see table 9), and the average for the whole season 1.203. The variation among trees, if tree N is excepted, is very small, thus exhibiting much uniformity.

6. The ratio of solids to acids averaged less than 7 in four trees, A, B, C, and J, and more than 7 in the other four. It increased steadily all through the season, going up to 8 on December 29th. The average for all trees for the season was 7.23. All of the trees, except tree A, reached a ratio of 7 during the course of the season between the extreme dates of October 5th and December 29th. The highest ratio reached by tree A was 6.9 on November 3rd. The average of all the trees came up to 7.2 on November 3rd.

7. The total sugars increased until a ratio of 7 was obtained. From this point on the sucrose suffered inversion, and no constant increase in total sugars could be noticed. The invert sugar increased continually. The averages for the season were 5.258 for total sugars, 3.045 for invert sugars, and 2.102 for sucrose. There was not much variation among the individual trees (see table 9), the total sugars specially showing uniformity. The inversion of sucrose after a ratio of solids to acid of 7 is obtained, is unmistakebly shown.

8. The per cent skin and the thickness of skin changed in a very irregular fashion, and the latter item only between very narrow limits. Between the ratios that obtained, they may be considered constant.

9. The invert sugar content has been higher than the sucrose content in every case.

All of the above observations point strongly to the conclusion that the juice of Duncan grapefruits contains a ratio of solids to acid equal to at least 7 when they are mature. They seem to reach this stage by the first week of November.

MARSH'S SEEDLESS, SEASON 1916–1917

The composition of the fruits picked on succeeding dates from four trees of the Marsh's Seedless variety are given below for each tree in tabular form:

INDIVIDUAL TREE RECORDS.

Mean composition of fruit for the whole season, per tree and on succeeding dates:

TABLE 11.

Analyses of Fruit (Marsh's Seedless) from Test Tree, Grove B, Vega Alta.

Date picked	Average weight	Average size	Color	Thickness of skin in inches	Per cent skin	Weight of fruit per box	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio invert sugar to sucrose
October [illegible]	489	54	Y. S. G. T.	9/32	28.07	23,706	48.35	7.8	1.16	6.7	2.44	4.40	1.84	1.326
November 21	440	63	G. Y.	5/16	23.14	27,720	51.50	7.6	1.05	7.2	2.69	4.65	1.84	1.462
December [illegible]	738	46	Y G. T.	5/16	28.13	33,718	45.45	8.0	1.00	8.0	2.93	5.14	2.09	1.402
January 18	508	54	Y S G. T	9/32	18.03	27,432	46.93	9.7	1.38	7.0	3.50	5.61	2.19	1.596
Averages for the season	530	54		19/64	24.31	28,894	48.06	8.27	1.147	7.21	2.89	4.963	1.99	1.452

TABLE 12.

Analyses of Fruit (Marsh's Seedless) from Test Tree, Grove L, Río Piedras.

Date picked	Average weight	Average size	Color	Thickness of skin in inches	Per cent skin	Weight of fruit per box	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio invert sugar to sucrose
October 3	499	36	G. Y. T	3/8	33.23	17,964	48.99	7.4	1.25	5.9	2.69	[illegible]	1.84	1.462
October 20	471	54	G. S. Y. T	3/8	30.80	25,434	45.91	7.5	1.15	6.5	2.44	4.16	1.60	[illegible]
November 14	446	54	G S. Y. T	3/8	31.21	24,084	46.15	7.3	1.10	6.6	3.67	4.16	0.57	[illegible]
November 21	468	54	G. S. Y. T	9/32	25.08	25,272	48.59	7.1	1.00	7.1	2.69	4.05	1.84	1.462
December 20	445	56	G. Y. T.	....	28.03	24,920	53.13	7.3	1.00	7.3	3.10	4.40	1.18	[illegible]
January 24	558	54	Y G. T.	1/4	29.86	30,132	46.41	6.9	.93	7.4	2.69	4.16	1.35	[illegible]
February 24	534	56	Y S G. T.	1/4	29.14	29,904	49.90	7.2	.95	7.6	2.93	3.91	[illegible]	[illegible]
Averages for the season	483	52		10/32	29.54	25,387	47.71	7.24	1.054	6.85	2.867	4.245	1.291	[illegible]

NOTE.—In working with the fruit a system of noting the comparative amounts of coloring was devised. In the charts letters are used to represent these as follows: G., green; Y., yellow; T., tinge; S., slight; B., bright; Q., quite. Various Combinations are employed.

TABLE 13.

Analyses of Fruit (Marsh's Seedless) from Test Tree, Grove M.

Date picked	Average weight	Average size	Color	Thickness of skin in inches	Per cent skin	Weight of fruit per box	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio invert sugar to sucrose
September 22	616	36	Y. G. T.	7/16	41.72	22,176	32.04	8.1	1.60	8.1	3.50	5.68	2.01	1.741
October 6	500	46	G. Y. T.	7/16	34.85	23,000	38.45	8.2	1.38	5.9	2.69	5.14	2.33	1.111
October 23	441	64	G. Y. T.	17/32	37.92	28,224	36.92	7.8	1.40	5.6	2.69	4.40	1.59	1.691
November 3	466	54	G. S. Y. T.	15/32	32.44	25,164	38.62	7.8	1.24	6.8	2.44	4.16	1.60	1.525
November 21	458	54	G. S. Y. T.	3/8	34.54	24,732	40.25	7.9	1.22	6.5	3.10	4.89	1.67	1.856
December 8	612	46	G. S. Y. T.	3/8	38.11	28,152	42.18	7.8	1.10	7.1	2.69	4.89	2.08	1.293
December 29	587	54	Y. G.	1/2	35.66	28,998	41.86	7.5	1.10	6.8	2.93	5.14	2.09	1.401
January 18	475	54	Y. S. G. T.	1/2	35.08	25,650	42.45	7.5	1.10	6.8	3.50	4.40	.78	4.487
March 9	561	46	Y. S. G. T.	5/16	32.27	25,806	46.52	7.1	.95	7.5	2.93	4.16	1.11	2.639
February 9	493	64	Y. G. T	5/8	33.10	31,552	46.97	7.6	1.06	7.2	3.67	5.14	1.35	2.718
Averages for the season	516.3	52		29/64	35.57	26,345	40.62	7.73	1.155	6.69	3.011	4.758	1.661	1.812

TABLE 14.

Analyses of Fruit (Marsh's Seedless) from Test Tree, Grove N.

SEASON 1916–1917.

Date picked	Average weight	Per cent skin	Thickness of skin in inches	Color	Average size	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio invert sugar cane to sucrose	Weight of fruit per box
October 6	525	26.11	1/4	G. Y. T.	46	45.28	7.9	0.85	9.4	2.93	5.14	1.99	1.478	34,130
October 23	487	27.62	1/4	G. Y. T.	64	45.60	8.5	1.19	7.1					31,168
November 3	371	28.87	3/4	G. S. Y. T.	60	40.49	9.6	1.27	7.5	2.93	5.87	2.82	1.039	22,260
November 21	541	25.10	9/32	G. S. Y. T.	54	47.53	8.5	1.00	8.5	3.91	5.63	1.60	2.448	29,214
December 8	562	20.00	5/16	G. Y.	54	43.20	9.0	1.15	7.9	2.69	4.89	2.08	1.293	30,848
December 29	441	24.61	5/16	Y. G.	64	46 15	9.0	1.15	7.8	3.50	5.38	1.76	1.988	28,224
January 18	287	24.05	7/32	Y. S. G. T.	72	47.75	8.5	1.08	8.2	4.40	6.11	1.59	2.767	20,664
Averages for the season	459	26.62	21/64		59	45.14	8.7	1.091	7.97	3.378	5 448	1.973	1.709	31,001

TABLE 15.

Showing Biweekly Analyses of Fruit Picked from Different Groves, B. L. M. N.[1]

SEASON 1916–1917) MARSH'S SEEDLESS.

Date picked	Average weight	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio o solids to acid	Invert sugar	Cane sugar	Total sugar	Ratio in-vert to cane sugar	Thickness of skin	Average size	Weight per box in March
September 22	616	32.04	41.72	8.10	1 100	8.10	5.50	2.01	5.63	1.741	7/16	36	22,176 Grm
October 3-6	508	31.39	42.57	7 83	1 278	6 15	2.77	2.08	4 97	1.331	11/32	48	21,844 "
October 20-23	459.5	31.30	42.95	7.90	1 225	6.74	2.52	1.48	4.32	1.702	12/32	59	27,110 "
November 3-14	427.6	30.84	41.82	8.23	1 200	6 86	3.01	1.60	4.73	1.881	12/32	56	23,945 "
November 21	476.7	27.44	49.35	7 88	1.067	7.33	3.20	1.57	4.39	2.038	10/32	56	26,695 "
December 8	587	34.05	42.69	8.40	1.125	7.46	2.59	2.08	4.80	1.293	11/32	50	29,350 "
December 20-29	539	33.81	45.51	7.90	1 062	7.43	2.96	1.95	5.08	1.518	12/32	55	29,645 "
January 18-24	457	26.75	45.88	8.15	1.110	7.24	3.54	1.60	5.12	2.212	10/32	59	26,968 "
February 9	493	33.10	46 97	7.60	1.060	7.17	3.67	1.35	5.14	2.718	5/8	64	31,552 "
February 24	584	29.14	49.90	7.20	0.950	7 507	2.93	0.86	3.91	1.407	1/4	56	29,904 "
Averages of all the trees for season	509.78	30.96	44.94	7.91	1.117	7.08	3 079	1 658	4,825	1.857	22/32	58	26,914

TABLE 16.

Showing Mean Composition of Fruit for Each Tree for the Season.

MARSH'S SEEDLESS (1916–1917).

Grove	Average weight in grams per fruit	Average size	Thickness of skin in inches	Per cent skin	Weight of fruit per box in grms.	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio of in-vert sugar to sucrose
B	530	54	9/32"	21.31	28,894	48.06	8.27	1.147	7.21	2.890	4.983	1.990	1.453
L	483	52	5/15"	29.54	25.387	47.73	7.24	1.054	6.86	2.887	4.245	1.291	2.236
M	516.3	52	14/32"	35.57	26.345	40.62	7.73	1.155	6.69	3.011	4.758	1.661	1.812
N	459	59	10/32"	26.62	31,001	45.14	8.7	1.091	7.91	3.373	5.448	1.973	1.709

[1] On each of the dates noted, 12 fruits were picked from each tree, and each sample was separately analyzed. The results of each set of four samples were then averaged, and the averages obtaiend are tabulated below.

DISCUSSION OF RESULTS OBTAINED WITH MARSH'S SEEDLESS (1916–17).

Weight and size.—Tree B. The tendency is to increase on the part of the weight; this is shown both by the weight of the individual fruits and by the weight per box. Notice that the first and last samples collected are both size 54, and that the weight per fruit of the first sample, which contains a higher per cent of juice is less than the weight per fruit of the second sample, with a lower juice content. This confirms observations made on Duncan fruit.

The size of the fruit is variable.

Tree L.—Again a tendency to increase in weight is noticed, especially among the figures showing weight per box. The samples picked on October 20, November 14, November 21, and January 24 are all of size 54. On inspection of the table it will be found that the samples with less juice show the greater weight per fruit.

The size of the fruit is tolerably uniform.

Tree M.—A slight tendency to increase in weight as shown by the weight per box. Compare the samples picked on November 3rd, November 21st, December 29th, and January 18th, all of size 54, The samples containing the most juice show the lower average weight per fruit.

Tree N.—There is much fluctuation.

Again, if fruits of the same size are compared as to weight, the larger weights are shown by the fruits having the smaller percentages of juice. Compare for instance the samples picked on November 21st and December 8th, both of size No. 54, and the samples picked on October 23rd, with that picked on December 29th, of size No. 64.

The table of averages shows an increase in weight per box as the season advances, but fails to support the assumption that higher weights per fruit are associated with lower juice contents.

The Marsh's Seedless, then, shows a tendency to increase in weight as the season advances, as shown by the weight per box. They, too, as the Duncans, appear to have more weight when the per cent juice is lower, if the comparison is made between fruits of the same size and from the same tree, but this is not uniformly so.

Per cent juice.—The tendency is to increase in fruits that have not reached yet a ratio of 7, as instanced by tree L. The first three samples picked from this tree averaged a ratio of solids to acid of 6.33 and their average juice content was 45.35 per cent. The last

four samples had all ratios larger than 7 averaging 7.35, and their juice content was 49.50 per cent. Not only this, but in the first three samples each increase in ratio was accompanied by a corresponding increase in juice. After the ratio of 7 is attained, the increase is not so regular, and the variations show considerable fluctuations, although the range is rather upward than downward.

The table of averages of all the trees through the whole season support the above coaclusions (see table 15). Thus the averages corresponding to October 3–6th, October 20th–23rd and November 3rd–14th, all have correspanding ratios lower than 7 (an average of 6.58), and the juice percentages corresponding to them average only 42.44 per cent. The rest of the average ratios are all higher than 7 (an average of 7.371) and the corresponding juice contents range from 41.72 to 49.90, averaging 46 per cent.

The juice in the Marsh's Seedless increases with perceptible regularity as the ratio of solids to acid increases, until a ratio of 7 is reached. Beyond this ratio considerable fluctuation occurs. This seems to point to the assumption that the Marsh's Seedless fruits reach maturity when they show a ratio of 7.

Per cent skin.—The skin decreases fairly steadily until a ratio of 7 is reached. Thereafter considerable fluctuation is noticed. With few exceptions the higher percentages of skin correspond with lower ratios. In tree B the first sample picked with a ratio of 6, had the highest percentage of skin, 28.07. Among the rest of the samples, all with ratios above 7, fluctuations occurred.

In tree L, the first three samples show ratios below 7, ranging from 5.9 to 6.6 with an average of 6.33, and their content of skin ranges from 33.23 per cent to 30.30 per cent with an average of 31.58 per cent. The succeeding samples have ratios ranging from 7.1 to 7.6 with an average of 7.35, and their percentages of skin fluctuate between 25.08 and 29.85 with an average of 28.02.

In tree M, arrange the ratios of solids to acids in an ascending order, and write opposite to each ratio its corresponding per cent skin, thus:

Ratio of solids to acids	Per cent skin
5.6	37.92
6.0	34.85
6.3	32.44
6.5	34.54
6.[illegible]	35.66
[illegible].8	35.08

Ratios.	Per cent skin.
7.1	38.17
7.2	33.10
7.5	32.27
8.1	41.72

Taking the averages of all samples with ratios up to and including 7.1, and of all those having ratios larger than 7 we get 35.51 per cent for the former and 35.69 per cent for the latter. In this instance no difference appears between the fruits with ratios below and above 7. It should be noticed, however, that except for the two exceptional cases of the samples with ratio 7.1 and 8.1 the individual figures suggest a decrease.

Tree N, does not show any fixed tendency, and the figures fluctuate considerably. It should be noticed that all ratios here are larger than 7.

Coming now to the table of averages of all trees for the whole season, and arranging as before, the average ratios in an ascending order with the corresponding percentages of skin opposite, we get:

Average ratio of solids to acid	Average per cent skin
6.15	31.39
6.74	31.30
6.86	30.84
7.17	33.10
7.33	27.44
7.34	26.75
7.36	32.04
7.43	33.81
7.46	34.05
7.507	29.14

Averaging the percentages of skin for all ratios below 7, a skin content of 31.04 per cent is obtained. The percentages of skin for all ratios above 7 average 30.90, thus showing a decrease as the ratio increased to 7.

The percentage skin, then, though within rather narrow limits and in an irregular fashion, suffers a decline as the ratio of the fruit approaches 7.

Thickness of skin.—After a ratio of 7 is reached no definite tendency is manifested. Before a ratio of 7 is reached, however, the thickness of skin diminishes as the ratio increases.

Thus, in tree L the thickness for the first three samples averaged

3/8″, while the thicknesses that follow, for fruits with ratios greater than 7, do not go beyond 9/32″ and average approximately 1/4″.

In tree M the samples with ratios below 7 average a thickness of 15/32″ while those with ratios above 7 average 14/32″.

In the other two trees all ratios reach and go beyond 7 (except for one sample in tree B, which has a ratio of 6.7), and no definite tendency is manifested. Considerable fluctuation occurs.

Turning to the table of averages for all the trees throughout the season (table No. 15), we find that the average of all the averages given for fruit with ratios lower than 7 is over 14/32″, while the average of all averages given for fruit with ratios higher than 7 is less than 12/32″. *There is, then, a tendency on the part of the skin to diminish in thickness as the ratios increase, which is chiefly noticeable before the fruit obtains a ratio of 7.*

Per cent solids in juice.—The solids for this fruit during this season may be considered as practically constant. In tree B an increase may be noticed, and so also in tree N, although to a lesser extent. Tree M, on the other hand, as well as the table of averages, shows a diminution, while in tree L this item may be considered as fairly constant. These observations are in accord with those made on the Duncan fruit.

The highest average shown for any tree was 8.7 for tree N, the lowest 7.225 for tree B, and the average of all the trees was 7.91. Among the averages of all trees for different dates, the lowest was 7.20 on February 24th, and the highest 8.40 on December 8th. Evidently these fruits contain less solids in solution than the Duncans.

Per cent acid.—Two things are to be noticed. First, that the per cent acid keeps on increasing until about November 21st, when it begins to decrease; and second, that, in general, the per cent acid varies in opposite direction to the ratio of solids to acids. That there is a very marked decrease in this factor is very plainly shown by the tables.

In tree B the decrease in acid begins on November 21st, the average of the last three samples, 1.143 being lower than the first figure, and so also the general average.

In tree L the decline in acid content takes place after November 21st, the average for the first three samples, with ratios below 7, being 1.166, while the average for the last four, with ratios above 7, is 0.97. The total average is less than the first figure, and the decrease in per cent acid follows closely the increase in ratio.

This close correspondency between decrease in acid and increase

in ratio is very strikingly shown, not only here but also by trees M and N.

Thus, arranging the ratios in their ascending order and writing opposite each their corresponding acid contents, we have:

TREE M.

Ratio.	Acid per cent
5.6	1.40
6.0	1.38
6.3	1.24
6.5	1.22
6.8	1.10
6.8	1.10
7.1	1.10
7.5	0.95
8.1	1.00

TREE N.

Ratio.	Acid per cent.
7.1	1.19
7.5	1.27
7.8	1.15
7.9	1.15
8.2	1.03
8.5	1.00
9.4	0.85

Turning now to the table of averages we find similar conditions established although fluctuations are more noticeable here. Arranging as before:

Ratios	Per cent acid
6.15	1.273
6.74	1.225
6.86	1.200
7.17	1.060
7.33	1.067
7.34	1.110
7.36	1.100
7.43	1.062
7.46	1.125
7.507	0.950

The decrease is plainly seen, and needs no further comment.

The per cent acid, then, decreases as the fruit matures and reaches higher ratios. Acid formation occurs only until a more or less definite point in the development of the fruit is reached, after which no more acid forms. This point seems to be reached almost at the same time that the ratio of 7 is reached.

Taking the averages of all the trees for different dates (see table 15) the lowest acid content, 0.95 per cent, occurred on February 24th, and the highest, 1.273, on October 3rd–6th. The average of all trees for the whole season was 1.117. This shows a lower acid content for Marsh's Seedless during 1916–17 than for Duncan fruit.

Ratio of solids to acids.—This ratio undoubtedly increases continuously until the ratio of 7 is fully established. Thereafter it continues to increase, but rather slowly, and with some fluctuations. It

should be noticed that this established ratio of 7, comes about some time near the 21st of November, coinciding thus with the time when the per cent acid begins to decline steadily and without interruption.

Tree B reached a ratio of 7 for the first time on November 21st, after which a ratio of 8 and one of 7 occurred in the two succeeding samples.

In tree L there is noticed a steady increase in the ratio, from 5.9 on October 3rd to 7.3 onNovember 21st, after which fluctuations occurred with very slight gains.

In tree M a ratio of more than 7 is obtained in the first sample. After this, a ratio of 6 which climbs up to 7.1 on December 8th is observed. The next two samples show ratios of only 6.8 each, after which the ratio does not fall below 7 again. It must be observed that for the three samples, corresponding to December 8th, December 29th, and January 18th, the per cent acid (of 1.10) is the same. The ratios are all so near 7 that for all practical purposes they might be taken, as 7. As to the first ratio, of 8.1, it clearly indicates that the fruit composing that sample must have been from an earlier bloom. This is supported by other data as well; as for sample, by its color, which was yellow, with only a green tinge, while all the samples immediately following were green, with only a tinge of yellow, and also its content of invert sugar and of sucrose, which are higher and lower respectively than those following. This sample, then, in all fairness, should not be compared with the rest of the table.

In tree N a ratio of more than 7 is established from the beginning, October 6th, and considerable fluctuation occurs.

Turning to the average of all the trees on different dates, (see table 15), and discarding the figure for September 22nd, as this is the ratio of the first sample of tree M just described (no other sample appears to have been picked on this date), we obtain a continued, uninterrupted increase in ratios, from 6.5 on October 3rd–6th up to 7.33 on November 21st. Hereafter all ratios show more than 7, but the increase is very slight and some fluctuation is noticed.

Color.—Again we find the green predominating, in spite of the fruit having reached a ratio of 7. It is only well towards the end of the season that the yellow becomes more prominent than the green. This again emphasizes the fact that grapefruit here does come up to a ratio of 7 early enough in its maturation period to justify the application of the standard to Porto Rico fruit. Usually the fruit which is quite near the neighborhood of 7 in ratio shows up more

green color than yellow, and when the yellow color predominates the ratio is generally in the neighborhood of 8.

This supports the view that the fruit comes to maturity when it has reached a ratio between 7 and 8, which is perhaps nearer 8 than 7. However, in the Marsh's Seedless maturity seems to come earlier than in the Duncan, judging from the fact that all signs of maturity, including color, appear earlier.

The lowest ratio of solids to acid (average of all trees) was 6.15 and occurred on October 3rd–6th, the highest was 7.507, which occurred on February 24th, and the average for the season was 7.08. These fruits reached the ratio of 7 pretty early in the season, but the ratios as a whole did not increase much beyond this point.

Per cent sugars.—Taking the averages of all trees for each one of the dates on which fruit was picked and arranging them in the ascending order of their corresponding ratios we obtain the following columns:

Ratio	Total sugars Per cent	Invert sugars Per cent	Cane sugars Per cent
6.15	4.97	2.77	2.08
6.74	4.32	2.52	1.48
6.86	4.78	3.01	1.60
	(4 575)	(2.766)	(1 72)
7.17	5.14	3.67	1 35
7.33	4.89	3.20	1.57
7.34	5.12	3.54	1.60
7.43	5.08	2.96	1.95
7.46	4.89	2.59	2.08
7.507	3.91	2.93	0.86
	(4.781)	(3 081)	(1.586)

The columns above the first line represent samples whose ratios were below 7, while those following are for samples whose ratios were above 7. The figures in parenthesis are averages.

The averages for total sugars have been calculated from those for invert sugar and sucrose.

As seen, the total sugars and the invert sugar show an increase, while the cane sugar, or sucrose, shows a decrease. The increase in total sugars, however, has been very slight, this demonstrating that the increase in invert sugars has been chiefly due to inversion. This statement is perfectly well proven by a simple calculation.

The difference between the averages for total sugars is 0.156 per cent. The difference between the averages of invert sugar is 0.315 per cent. Calculating the averages for cane sugar to their invert sugar equivalents we have 1.72 cane sugar equivalent to 1.809 invert sugar, and 1.586 cane sugar equivalent to 1.650 invert sugar. The

difference between these two invert sugar equivalents is 0.159. That is the cane sugar inverted is equivalent to 0.159 invert sugar. Out of a total increase of 0.315 per cent in invert sugar, 0.159 per cent has been due to inversion of sucrose.

The difference between the total increase in invert sugar, and the increase due to sucrose inversion ought to approximate the increase in total sugars. In this instance they are identical. Thus, the above referred to difference is 0.156 per cent (0.315 minus 0.159) and the difference in total sugars is, as noted above, 0.156. There is no question, then, as to the inversion of sucrose when the ratio of 7 is reached. This proves that the Marsh's Seedless reach maturity when a ratio of 7 is present. This makes the Marsh's Seedless reach maturity with a little lower ratio than the Duncans.

Summarizing the results obtained for Marsh's Seedless for this season we have:

1. The weight per fruit is rather constant for the ratios and sizes examined. Among the trees the average weights varied between 459 and 530, the average of all being 509.78 grams: The average sizes varied among the trees from 52 to 59 the average of all being 53. The average weight per box was 26.914 kgms., and showed a marked increase throughout the season. The trees varied among themselves from 25.387 to 31.001 kgms. per box.

2. The per cent skin was rather constant and high, the average of all trees for the season being 30.98 per cent. There was no uniformity among trees, the skin content varying from 24.31 per cent, the average for tree B to 35.57, the average for tree M.

3. A fair percentage of juice was shown, the average of all trees for the season being 44.94 per cent. The trees varied in their averages from 40.62 per cent (tree M) to 48.05 per cent (tree B). Toward the latter part of the season the fruit contained more juice than at the beginning, a notable increase being evident after November 21st.

4. The solids in solution are rather low, the average of all trees for the season being 7.[illegible] per cent. The averages of the individual trees ranged from 7.24 per cent to 8.7 per cent. This item showed frequent fluctuations, and may be regarded as constant for the ratios under consideration.

5. The per cent acid showed a perceptible decline. The average for all the trees for the season was 1.117. The individual trees ranged from 1.054 to 1.155, thus showing a fair degree of uniformity.

6. The ratio of solids to acids increased, but at a slow rate. The rate of increase in this instance is considerably lower than in the Duncan fruit, and the ratios obtained lower also. The ratio of solids to acid of all trees for the season was 7.08 as against 7.23 for the Duncan. In no instance was a ratio of 8 obtained, the highest being 7.507. This fruit reached an approximate ratio of 7 almost at the same time as the Duncans, between November 3rd and 21st. The averages for the individual trees ranged between 6.69 and 7.91.

7. The total sugars, as well as the invert sugar were higher toward the latter part of the season, after November 21st. The sucrose was lower toward the end of the season. The averages were 4.825 total sugars, 3.079 invert sugar, and 1.658 sucrose. This gives the Marsh's Seedless a little less sugars than the Duncans. The ratio of invert sugar to sucrose is much higher for the Marsh's than for the Duncans, for the former being 3.857 and for the latter 1.448.

The averages for the individual trees showed a fairly good agreement in regard to these items as may be seen from table No. 16.

In substance—

1. The Marsh's Seedless fruit juice also contained during this season solids in solution in a proportion which was at least seven times the proportion of acid it contained at maturity.

2. This proportion of solids to acids came about some time during the latter part of November.

3. The changes undergone by this fruit were pretty nearly of the same nature as those undergone by the Duncan, only they differed in extent and rate at which they proceeded.

4. The fact that most of the changes noticed proceed regularly, or nearly so, until a ratio of more or less 7 is reached, and that the inversion of sucrose occurs after this ratio obtains, point to this ratio as marking the point of maturity of the fruit.

TRIUMPH GRAPEFRUIT, SEASON 1916–1917.

INDIVIDUAL TREE RECORDS.

Only two trees, located in two different groves, A and K, were used for this series of tests.

Below are given two tables showing the composition of the biweekly samples picked from each tree:

TABLES SHOWING BIWEEKLY ANALYSES—FRUITS FROM TWO DIFFERENT GROVES.

TABLE 17.

Analyses of Fruit (Triumph), Test Tree, Grove A, Pueblo Viejo.

Date picked	Average size	Average size	Color	Thickness of skin in inches	Per cent skin	Weight of fruit per box	Per cent juice	Solids in juice	Acid (acid)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio invert sugar to sucrose
October [illegible]	525	64	G. S. Y T	5/16	33.73	33,600	30.73	8.9	1.04	8.5	2.19	5.63	3.32	0.659
October 23	325	64	Y. G. T.	7/32	30.00	20,800	36.69	8.8	.94	9.3	2 44	5.63	3.07	0.794
November 8	460	80	Y. G. T.	1/4	26 99	36,800	35 40	9.5	.95	10.0	2 69	6.11	3.30	0.815
November 21	359	64	G S. Y. T.	1/4	22,87	22,176	39.41	9 5	.95	10.0	3 50	6.11	1.49	2 349
December 8	484	64	Y. G T.	1/4	31 52	30,976	36 14	9.3	.82	11.3	2.44	6.38	3.80	0.642
December 29	496	64	Y G. T	1/4	28 57	31,744	31.69	9 5	.70	13.6	2.98	5.87	2.82	1.089
January 18	485	64	Y S. G. T.	1/4	24 13	31,040	31 96	9 0	.76	11.8	3 10	5.14	1.92	1 614
February 9	491	54	G. Y	1/4	30 93	26,914	29.66	9.5	.70	13.57	3.50	6.36	2.74	1.277
Averages for the season	453	64		1/4	28.88	29,356	33.96	9.25	0.857	10.79	2.847	5 7909	2.807	1.014

TABLE 18.

Analyses of Fruit (Triumph), Test Tree, Grove K, Pueblo Viejo.

Date picked	Average weight	Average size	Color	Thickness of skin inches	Per cent skin	Weight of fruit per box	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio of invert sugar to sucrose
September 22	332	96	G. Y.	1/4	31.55	31,872	24.45	9.8	1.08	9.0	2.98	7.09	4.04	0.738
October 6	333	96	G. S. Y. T	1/4	31.10	31,968	27.02	10.4	1.05	9.9	2.69	7.33	4.52	0.595
October 28	355	96	G. Y. T.	5/16	31.76	34,080	25.98	10.1	1 03	9 8	2 98	6.36	3.31	[illegible]
November 8	329	100	Y. G. T.	7/32	25 96	32,900	32 45	10.7	.90	11.6	2.93	6.84	3.79	0.773
November 21	290	100	G. S Y. T.	1/4	24.42	29,000	32 55	10.8	.88	12.3	3 67	7.09	3 30	1.112
December 9	316	120	G. Y. T	1/4	25.07	37,920	37.00	10.4	.88	10.0	3.10	7.33	4.11	0.754
December 29	281	100	Y. G. T.	....	22.22	28 200	40.00	11.0	.76	14.5	3.91	6.84	2.81	1.391
January 18	325	68	Y. S. G. T.	3/8	41 02	22,100	38.28	11.6	.76	15.1	3.91	7.31	3.78	[illegible]
Averages for the season	320	97		15/64	29 13	30,998	32.21	10.58	0.917	11.58	3.265	6.894	3.457	0.942

By averaging the results obtained for the samples picked on the same date, the following table to show the mean composition of the fruit on succeeding dates was constructed:

TABLE 19.

Showing Biweekly Analyses of Grapefruit from Two Different Groves.

TRIUMPH, SEASON 1916–1917.

Date picked	Average weight	Per cent skin	Per cent juice	Per cent solids	Per cent acids	Ratio of solids to acids	Invert sugar	Cane sugar	Total sugar	Ratio invert to cane sugar
September 22...	382.	31.35	24.45	9.8	1.08	9.0	2.98	4.04	7.18	0.725
October 5-6...	429.	32.41	28 87	9.6	1.04	9.2	2 44	3.92	6.566	0.620
October 28...	340.	30.88	31.31	9.45	0.99	9.5	3.18	3.19	6.589	1.000
November 8...	394.5	26.47	38.92	10.10	0 92	10.9	2.81	3.54	6.587	0.790
November 21...	324.5	28.64	35.96	10.1	0 91	11.1	3 58	2.39	6.090	1.500
December 8...	400.	28.29	36 57	9 8	0.85	11.15	2.77	3.95	6.929	0.700
December 29...	388 5	25.39	35.84	10.3	0 78	14.1	3.42	2.81	6 379	1 210
January 18...	405.0	32 57	35.12	10.2	0 76	13.4	3.50	2 85	6.500	1.28
February 19...	491.	30 93	29.66	9.5	0.70	13.57	3.50	2.74	6.385	1.27
Average for the season.......	387.16	29.10	32.41	9.872	0.887	11.12	3.125	3 27	6 568	0.9556

On each of the dates noted samples of 12 fruits were picked from each of two trees and were separately analyzed. The averages of the samples collected on each separate date are presented above.

From the two previous tables, the following, showing the mean composition of the fruit from each tree, was abstracted:

TABLE 20.

Showing Mean Composition of Fruit for Each Tree for the Season.

TRIUMPH, SEASON 1916–1917.

Grove	Average weight	Average size	Per cent skin	Thickness of skin in inches	Per cent juice	Weight of fruit per box in Grm	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio of invert sugar sucrose
A	458	64	28.38	1/4	33.96	29,356	9.25	0 857	10.79	2.647	5 800	2 807	1.014
K	320	97	29.13	15/64	32.21	30,993	10.58	0 917	11 53	3.258	6.894	3.457	0.942

SEASONAL CHANGES, 1916–1917.

An examination of the tables will reveal some interesting differences between this variety and the other two already studied.

Two distinctly different sizes were chosen—the fruit picked from tree K, being small, of average size number 97, and the fruit from tree A, which was of medium size, average size number 64, more or less.

Eliminating the two samples not of size 64, in tree A, and comparing all the others, of size 64, as to weight, an increase in weight per fruit is noticed from October 23rd on.

On this same date a decline is noticed in acid, and with only one exception all samples thereafter show up more color.

The ratio increases continuously and practically without interruption, while the solids increase also almost continuosly after October 23rd, and the percentage of skin drops to a lower level on this date also and stays lower in all the succeeding samples except two.

There is a slight increase in total sugars, but no steady gains are evident, and the same might be said in regard to invert sugar, although in the latter the gain is more pronounced than in the former. The percentage of cane sugar decreases, although fluctuations are noticeable. The ratio of invert sugar to sucrose gains from the very beginning so that higher inversion is present from the start, or the formation of invert sugar proceeds at a faster rate than that of sucrose. The above data may suggest that this fruit came to full maturity some time around October 23rd.

In tree K the weights per fruit and per box show no regular increases or decreases Fluctuations occur due to differences in sizes, but taking all in all this item may be conidered as fairly constant.

The percentage of acid shows small decreases from the beginning, but on November 3rd it drops considerably to a much lower level, and keeps on the decline to the very end.

The juice content also increases from the beginning, but a decided gain does not occur until November 3rd.

The ratio shows also a perceptible increase on November 3rd, while the color assumes a more yellowish hue (with one exception) after this date.

The total sugars may be regarded as tolerably constant, while the invert sugar shows a perceptible gain on November 21st and the cane sugar, with only one exception, is lower for the samples picked after this date. The ratio of invert sugar to sucrose is greater than unity for the first time on November 21st.

In the case of this tree the fruit probably came to full maturity some time between November 3rd and November 21st.

Both these tables again confirm the observation that the fruits with the higher percentage of juice exhibit a lower weight per fruit.

Turning now to the table of averages (No. 19) we find that on November 3rd the following observations may be made: The skin and the acid have decreased, while the juice, solids and ratio have increased. The cane sugar shows evident signs of inversion on November 21st. With few exceptions these lower and higher levels are respectively maintained on succeeding dates.

It will be noticed that all the changes which may be taken as marking the point of maturity of the fruit, occur in this variety somewhere near the same date as with the other varieties October 23rd to November 21st, but with a much higher ratio, usually in the neighborhood of 11. The writer is inclined to believe that this fruit does not reach maturity under local conditions with a ratio of 7, but with much higher one, only that its very low acid content makes it appear with a legal ratio of 7 quite early, before it really is mature.

It will thus be seen that this variety reaches the legal ratio of 7 very early in the season, but it is doubtful whether this means real maturity, at that early date.

It should be noticed that the per cent solids is much higher and the per cent acid much lower in this variety than in the other two, facts which account for the high ratio exhibited by this variety, which reaches limits to which the others do not even approach. This accounts for the staleness and lack of body of the juice, which is rather insipid. The fruits of this variety contain less juice than those of the other two. They contain more sugar and a closer ratio of invert sugar to sucrose, in many instances the sucrose being higher, a condition very rare in the other two varieties. The total average shows the proportion of the two sugars to be about equal, with the sucrose slightly higher.

Comparing the two trees selected among themselves, we find that although there is great difference in size and weight per fruit of the fruit picked from each one, yet they agree pretty closely in all other points of comparison.

CONCLUSIONS FOR THE SEASON 1916–1917.

The data for this season suggest that there are a number of changes in the appearance and composition of the fruit the direction, rate, or nature of which may serve to indicate the point of maturity of a grapefruit. These changes are, mainly, the color of

the fruit, the gain in juice, the reduction of the rind, the increase of the ratio of solids to acids in the juice, the increase of invert sugar, and the reduction of sucrose in the juice.

These changes occur to a greater or lesser extent in all three varieties, but the extent to which they occur and the rate at which they proceed seem to differ for each variety.

Based on the changes noted above, the conclusion is possible that a grapefruit, no matter of which one of the three varieties tested, when matured, always presents a ratio of solids to acids in solution in its juice of at least 7. The "Triumph" variety under our local conditions comes to maturity with a ratio of solids to acids much higher than 7, and probably between 10 and 11. All three varieties came to maturity some time during the month of November, but the "Triumph" reached the legal ratio of 7 much earlier in the season, as the first sample picked on September 22 already had a ratio of solids to acid equal to nine.

SEASONAL CHANGES, SEASON 1917 TO 1918

For this season's work, ten trees were selected in ten different groves, which included some of the groves of the previous year, and some new ones. Of the ten trees selected, seven were of the Duncan variety and three of the Marsh's Seedless variety. The trees were designated this time by numbers instead of letters. No analysis of soils or determination of sugars were conducted during this season, for lack of help.

The places in which trees were selected and the type of soil in which each tree stood were as follows:

Tree No	Owner or Manager of grove	Location	Type of soil
	DUNCAN		
2	Mr. Newton	Bayamón	Clay
3	Mr. L. W. Davis	Vega Alta	Clay
4	Mr. E. D. Stevens	Vega Alta	Sand
6	Mr. M. L. David	Vega Alta	Clay loam
8	Mr. W. K. Kaehrle	Vega Alta	Sand
10	Mr. R. L. Mills	Pueblo Viejo	Clay
11	Mr. Guildermeister	Pueblo Viejo	Sand
	MARSH'S SEEDLESS TREES		
5	Mr. E. D. Stevens	Vega Alta	Sand
7	Mr. W. K. Kaehrle	Vega Alta	Sand
9	Mr. Stanwood		

INDIVIDUAL TREE RECORDS.

DUNCAN.

The results obtained for each tree are given below in tabular form.

TABLE 21.

Individual Tree Records.

SEASON 1917–1918.

Each of these tables was constructed as follows: Ten fruit were picked from the tree to which the table refers on each of the dates noted. This fruit was immediately analyzed, and the results tabulated as herein shown.

TREE No. 2—DUNCAN.

Date picked	Average weight	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	Average size	Weight per box in grams
September 21	614.25	1/4	22.11	48.07	8.50	1.028	8.2	46	25,255
October 4	635 55	1/4	22.30	41.60	8.5	1.017	8.3	41	26,050
October 25	691.59	1/4	26.22	40.98	8 67	1.086	8.36	42	29,046
November 1	670 25	1/4	21.66	38.38	8 60	1 000	8.60	42	28,570
December 10	667.00	1/4	25.90	48 10	8.65	1,000	8.65	36	24,012
January 17	552 00	3/16	25.00	48.00	8.20	0.983	8 80	57	31,464
Averages for the season.........	645.07	1/4	23.86	40.84	8.52	1.002	8.50	44	27,900

TABLE 22.

TREE No. 3—DUNCAN.

Date picked	Average weight	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	Average size	Weight per box in grams
September 22	576.5	1/4	25.6	42.60	9.15	1.318	6.96	48	27,672
October 4	586.16	1/4	26.0	38.55	9.15	1.242	7.36	?	....
October 25	....	....	....	....	....	....	....	....	....
November 12	646.28	1/4	21.66	31.57	8.7	1.017	8.55	48	31,019
December 10	586	1/4	28.5	44.0	8.45	0.94	8.90	49	28,714
January 17	552	3/16	25.0	43.0	8.22	0.93	8.80	57	31,454
Averages for the season.........	589.86	1/4	24.85	39.94	8.734	1.088	8.08	40.4	29,717

TABLE 23.

Individual Tree Records—Continued.

SEASON 1917–1918.

TREE No. 4—DUNCAN.

Date picked	Average weight	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acids	Average size	Weight per box in grams
September 21	510.3	7/32	24.2	47.2	8.5	1.328	6.4	56	28,578
October 4	576.32	1/4	21.90	40.16	8.75	0.939	9.31	54	31,121
October 25	546.23	7/32	22.41	40.00	8.82	0.967	8.97	57	31,135
November 12	623.56	7/32	20.00	40.00	8.9	0.850	10.47	49	30,564
December 10	618	5/16	22.00	40.90	9.10	0.840	9.20	42	25,976
January 17	....	....	.. ....	....	....	....	....	....	....
Averages for the season...	574.88	7/32	22.10	41.65	8.814	0.9886	8.91	51.60	29,472

TABLE 24.

TREE No. 6—DUNCAN.

Date picked	Average weight	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	Average size	Weight per box in grams
September 21	491.8	5/16	28.86	33.17	9.61	1.718	5.59	59.	29,016
October 4	466.19	1/4	25.06	58.70	9.98	1.310	7.58	64.	29,886
October 25	424.29	1/4	15.55	37.77	9.85	1.311	7.51	72.	30,549
November 12	476.17	9/32	26.19	33.33	9.60	1.090	8.80	64.	30,475
December 10	391.00	1/4	25.00	31.00	9.80	1.350	7.26	74.	28,934
January 17	....	....	.. ....	....	....	....	....	....	....
Averages for the season.........	449.89	1/4	24.12	38.79	9.76	1.356	7.19	66.6	29,762

TABLE 25.

TREE No. 8—DUNCAN.

Date picked	Average weight	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	Average size	Weight per box in grams
September 21	468.05	1/4	28.82	40.31	10.08	1.575	6.40	54	25,004
October 4	566.80	1/4	22.50	41.66	9.98	1.427	6.29	54	30,607
October 25	736.98	11/32	29.28	32.80	9.20	1.478	6.22	40	29,477
November 12	634.90	9/32	23.21	32.14	9.50	1.496	6.35	48	30,475
December 10	680.00	5/16	21.70	39.00	9.65	1.330	7.25	42	26,560
January 17	713.00	9/32	25.00	38.00	9.55	1.190	8.00	39	27,307
Averages for the season.........	633.45	9/32	25.07	37.32	9.49	1.416	6.70	45.8	28,654

TABLE 26.

Individual Tree Records—Continued.

SEASON 1917–1918.

TREE No. 10—DUNCAN.

Date picked	Average weight	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	Average size	Weight per box in grams
September 21	....	....	....	....	....	....	....	....	....
October 4	523.90	1/4	24.50	43.20	10.60	1.690	6.27	59	39,940
October 25	408.90	7/32	25.00	33.33	10.55	1.662	6.34	72	20,876
November 12	476.17	1/4	23.80	33.33	10.80	1.518	7.11	67	31,908
December 10	575.00	1/4	24.00	44.00	10.40	1.370	7.59	48	27,600
January 17	552.00	1/4	27.00	41.00	11.10	1.550	7.16	57	31,464
Averages for the season.........	507.01	1/4	24.86	38.09	10.69	1.558	6.86	60.6	30,256

TABLE 27.

TREE No. 11—DUNCAN.

Date picked	Average weight	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	Average size	Weight per cent in grams
September	....	....	....	....	....	....	....	....	....
October 4	585.77	5/16	26.60	33.30	8.80	1.287	6.83	54	31,631
October 25	555.54	3/8	18.36	44.90	8.65	1.434	6.03	52	28,868
November 12	566.87	5/16	26.00	29.00	9.00	1.500	6.00	54	29,610
December 10	580.00	5/16	32.00	39.00	8.90	1.260	7.06	44	25,520
January 17	563.00	9/32	28.00	34.70	8.75	1.250	7.00	51	28,713
Averages for the season.........	570.24	5/16	26.19	24.88	8.82	1.346	6.55	51	29,072

In the table below the results presented were obtained by finding the averages of the analyses of all samples picked on the same date, for the dates noted. Ten to twelve fruits were picked from each tree.

TABLE 28.

Showing Biweekly Analyses of Duncan Grapefruit.

Sampled from seven different trees, and analyzed immediately after picking.

SEASON 1917–1918—DUNCAN.

Date picked	Average weight	Per cent skin	Per cent juice	Per cent solids in juice	Per cent (citric) acid	Ratio of solids in acids
September 21	548.21	25.18	41.51	8.94	1.247	7.280
October 4	562.92	24.12	42.52	9.24	1.273	7.420
October 25	560.48	22.79	36.21	9.29	1.318	7.288
November 12 17	586.80	23.13	32.24	9.30	1.210	7 98
December 10	585 28	24.87	44.14	9 28	1.256	7.988
January 17	595 00	26.25	39.17	9.40	1.280	7 740
Averages for the season	578.02	24.39	36 97	9.24	1.2565	7 36

The averages for each tree for the season may be seen in the table that follows:

TABLE 29.

Showing Mean Composition of Fruit for Each Individual Tree for the Season.

DUNCAN—SEASON 1917–1918.

Tree No.	Average weight per fruit in grams	Average size	Thickness of skin in inches	Per cent skin	Weight of fruit per box in grams	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids in acid
2	645.0	44	1/4	28 86	27,900	40.84	8 520	1.002	8 50
3	589 4	40	1/4	24.65	29,717	39.94	8.784	1.086	8 08
4	574.88	51	7/32	22 10	29,472	41.65	8.814	0.988	8.91
6	449.89	66	1/4	24 12	29,762	38.79	9.760	1.356	7.19
8	682 45	46	9/32	25 07	28,654	37.32	9.49	1.416	6.70
10	507 00	50	1/4	24.86	30,256	28.97	10.61	1 558	6.86
11	570.24	51	5/16	26.17	29,072	34.85	8.82	1.346	6 55

SEASON 1917 TO 1918.

DUNCAN.

Size.—The size of the fruit has been mostly in the neighborhood of 46 and 54. Of 44 samples measured 19 ran from 40 to 49, while 16 varied between 51 and 59. This coincides with the observations made during the season 1916 to 1917. There is no definite connection shown between the time of picking and the size of the fruit. This may be due to the mixture of fruits from different blooms on the trees, and the practical impossibility of being absolutely sure

that every fruit picked on successive dates came from the very same bloom.

Weight.—Of the seven trees tested during this season, in four of them, trees Nos. 2, 3, 4 and 8, the weight of the fruit has increased throughout the season, while in the remaining four a decrease has been noticed.

As regards the relation previously noted between weight of fruit and per cent juice, it is very difficult to establish any comparison, due to the great variation in the sizes of the samples obtained. But if we compare samples of approximate sizes from the same trees, the same relation, with a few exceptions, is found to exist.

In tree No. 2, taking the first four samples in the table, we find the percentage of juice decreasing from September to November, and the average weight per fruit increasing in the same order. Again, in tree No. 3, taking the samples corresponding to September 22nd and November 12th and December 10th, we find that the sample for November 12th, with the lowest per cent of juice, 31.57 per cent, shows the highest weight per fruit, 646 grams.

The same is evidenced by the three first samples of tree No. 4 and the samples for October 25th, and November 12th of tree No. 11.

Per cent juice.—Contrary to last season's results, the per cent juice this year has not shown any tendency to increase, but has rather exhibited fluctuations pointing to a decrease, although in many instances a gain was made toward the last of the season. This is shown not only by the tables for individual trees, but also by the table of averages, No. 28. This may be due to the fact that the fruit matured rather early this season.

The average for all the trees for the whole season was 38.97 per cent, lower than last year, which was 43.57 per cent.

Per cent skin.—In four cases, trees Nos. 3, 4, 6 and 8, the per cent skin showed a tendency to decrease, while in two cases it remained practically constant, and in one increased. This decrease in the per cent skin is also noticed in the table of averages.

Thickness of skin.—An examination of the tables of individual trees shows that this item is practically constant through the season. This is a sign that the fruit were already fully developed when the first sample was picked.

Per cent solids in juice.—The records for the individual trees show this factor to be practically constant through the season. In two cases, trees Nos. 4 and 6, a small, but perceptible increase is

noticed. In trees Nos. 2, 10, and 11, increases in the hundredths were noticed, so that they may be regarded as showing constancy. In the other two trees slight decreases were manifested. However, the table of averages for all the trees (No. 28) shows a small but marked increase as the season advances. This coincides exactly with previous observations. The average for all the trees for the whole season was 9.24 per cent, higher than last season's.

Notice that the solids are higher and the per cent juice lower for this season than for last.

Per cent acid.—In all cases except one, tree No. 11, the per cent acid has decreased as the season advanced. This is also shown by the table of averages. The lowest average shown by all the trees was 1.155 on December 10th, and the highest 1.347 on September 21st. The average of all the trees for the whole season was 1.255. This makes the acid content of the Duncans practically the same as for last season, when the minimum average shown by all the trees was 1.11 on December 29th, the highest 1.36 on September 25th, and the average of all the trees for the whole season 1.205.

The observations of this year in this respects coincide with those for last.

Ratio of solids to acids.—An examination of the tables will show a steady gain in most instances. In only one instance, tree No. 2, was the ratio from the beginning higher than 7, and even here, a slight, but steady gain was observed. The fruit from this tree started with a ratio of 8.2 on September 21st, and gradually and uninterruptedly climbed up to 8.80 on January 17. It should be noticed, however, that the rate of increase is very slow. In all other instances the fruit started with ratios lower than 7, even as low as 5.59, as in tree No. 6, and ended with ratios higher than 7, even as high as 9.20 as in tree No. 4, which started with a ratio of 6.4. This increase is shown by the table of averages, although not so clearly as by the individual trees.

Taking the averages for all the trees on different dates we find the lowest average ratio occuring on October 25th, which was 7.238, and the highest on December 10th, which was 7.998. The average ratio of all the trees for the whole season was 7.36. This is slightly higher than the average ratio for 1916 to 1917, which was 7.23. In this season all the averages given for the different dates, beginning September 21st, are higher than 7, while the corresponding averages for 1916–17 are lower than 7 for the first three pickings, namely, September 25th, October 6th, and October 24th.

During the season 1917 to 1918, then, we have less juice in the fruit, more solids, practically the same acid, and very slightly higher ratios than during 1916 to 1917. The weight per fruit was higher in the previous season.

The mean composition of the Duncan fruit for the two seasons surveyed has been as follows:

Season	Weight per fruit in grams	Percent skin	Percent juice	Solids in juice	Acid (citric)	Ratio of solids to acid
1916-17...........	602	28.25	43.57	8.70	1.208	7.28
1917-18...........	573	24.29	38.97	9.24	1.255	7.35

In a general way, the nature of the changes observed during this season has been the same as last, although there have been some differences as to the extent of the changes. This may be due to meteorological conditions, as well as to the fact that the trees used were not in every instance the same as those used last season. However, this last supposition is disproved by the facts if we compare the records for both seasons of only those trees that were continuously tested from 1916 to 1918. Following is a comparison. The trees were designated during the season 1916–17 by letters and during 1917-18 by numbers. The equivalences are as follows:

Grove	Designation during 1916-17	Designation during 1917-18
Mr. Newton	I	2
Mr. E. D. Stevens..............................	N	4
Mr. M. L. David	B	6

As seen, then, tree I and tree No. 2 are the same; so are tree N and tree No. 4, and tree B and tree No. 6.

Their records compare as follows:

Tree No.	Weight per fruit	Thickness of skin	Percent skin	Percent juice	Solids in juice	Acid (citric)	Ratio of solids to acid
Tree I	657	5/16	27.59	42.51	8.64	1.124	7.69
No. 2.....	645	1/4	28.86	40.84	8.52	1.002	8.60
Tree N. ...	471.6	1/4	27.99	42.77	8.62	1.166	7.39
No. 4.....	575	7/32	22.10	41.66	8.81	0.989	8.91
Tree B.....	450.8	1/4	27.10	45.74	8.46	1.252	6.76
No. 6.....	449.9	1/4	24.12	38.79	8.76	1.356	[illegible]
Averages for 1916-17......	526.6	7/32	27.56	43.64	8.56	1.514	[illegible]
Averages for 1917-18......	556.6	1/4	23.86	40.42	8.86	1.115	[illegible]

The very same trees, then, showed a record in 1917–18 different from that of 1916 to 1917, and the differences noted are of the same order as those found among the averages of all trees tested for the two seasons.

The changes undergone by Duncan fruit during this season, are much less pronounced than during season 1916–1917; in fact, some of them are totally absent, as no regularity in the variations have been detected. Only the slight decrease in acidity of the juice and a corresponding increase in the ratio of solids to acids have been at all regular.

To account for this lack of uniformity in behavior, reference must be made to the fact that the fruit showed a ratio of over 7 with the first sample picked on September 21st. It was observed the previous season, that when maturity was reached, the progressive changes in the fruit ceased to be regular, and fluctuations due to individual variations were apparent. The data on inversion of sucrose which, as was seen, exhibited regularity precisely after maturity are not available to judge the behavior of the fruit during this season, but with the data at hand we are safe in assuming that this fruit was ripe already when the first sample was picked, so that the changes which make for maturity had already taken place, at least, to a very large extent.

As will be seen further on, this early maturity may be ascribed to a reduction in the rainfall, which also accounts for the lower juice content and higher solids in juice found in this season's fruit.

Again, the fruit exhibited a ratio of over 7 when matured. Both maturity and ratio were reached very early this season. Most of the trees had matured fruits in October.

SEASONAL CHANGES, 1917–1918.

MARSH'S SEEDLESS.

Only three trees of this variety were tested during this season trees Nos. 5, 7, and 9. The composition of their fruit was found to be a follows:

TABLE 30.

Individual Tree Records.

SEASON 1917–1918.

TREE No. 5—MARSH'S SEEDLESS.

Date picked	Average weight	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acids	Average size	Weight per box in grams
September 21	444.15	5/16	26.85	42.55	7.81	1.187	6.880	64	28,425
October 4	412.27	1/4	25 00	45.00	7.98	1.121	7.00	72	29,683
October 25	510.18	5/16	26.66	42.26	7 63	0,963	7 92	61	30,121
November 12	532.86	5/16	25.58	38.38	7.30	0.876	8 38	57	30,878
December 10	506.00	1/4	27.00	47.00	7.20	0.880	8.19	62	31,372
January 17	....	....	....	....	....	... .	....	....	... .
Averages for the season	481.09	9/32	26 21	43.01	7.57	0.995	7.60	63	20,994

TABLE 31.

TREE No. 7—MARSH'S SEEDLESS.

Date picked	Average weight	Thickness of skid	Per cent skin	Per cent juice	Per cent solid	Per cent acid	Ratio of solids to acid	Average size	Weight per box in grams
September 21	652.05	5/16	28.90	38.4	9.26	1.452	6.37	46	29,994
October 4	....	....	....	....	....	....	....	....	....
October 25	555.54	9/32	24.48	32.65	10 00	1 541	6.48	59	22,777
November 12	586.86	1/4	28.40	30.00	9 80	1.475	6.64	60	32 881
December 10	609.00	5/16	28.00	36.00	9.90	1.350	7.33	46	28,014
January 17	644.00	1/4	27.00	42.00	9.70	1.28	7.60	48	30,912
Averages for the season	599.89	9/32	26.36	35.81	9.73	1.419	6.85	51.8	28,806

TABLE 32.

TREE No. 9—MARSH'S SEEDLESS.

Date picked	Average weight	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	Average size	Weight per box in grams
September 28	421.2	5/16	25.54	46.15	8.20	1.325	6.18	66	28,641
October 4	415.70	1/4	26.30	47.72	8.30	1.315	6 33	64	28,005
October 25	....	....	....	....	....	....	....	....	....
November 12	464.84	5/16	26.62	41.46	8.10	1.097	7.38	64	29,749
December 10	486.00	5/16	23.33	45.00	7.70	1.050	7.31	60	28,980
Averages for the season	446.16	9/32	25.82	45.08	8.05	1.197	6.72	64	28,426

TABLE 33.

Showing Biweekly Analyses of Fruit Picked from Three Different Groves.

On each one of the dates noted 12 fruits were picked from each of three trees set aside in three different groves, and the samples thus collected were separately analyzed. The results of the samples picked on the same date were averaged, and the averages are tabulated below.

SEASON 1917–1918—MARSH'S SEEDLESS.

Date picked	Average weight	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	Average size	Average weight per box
September 21–28	495.11	28.85	41.97	8.88	1 372	6.48	46	22,775
October 4	418.98	25.65	46.86	8.06	1.318	6.61	68	28,151
October 25	582.86	26.57	37.44	8.81	1.253	7.08	60	31,972
November 12–17	512 18	25.25	36.56	8.40	1.149	7.31	60	30,731
December 10	582 50	29.44	42.66	8.26	1.098	7.55	56	29,820
January 10	644 00	27.00	42.00	9.70	1.280	7.60	48	30,912
Averages for the season	521.78	26.87	41.16	8.67	1.227	7.09	56	29,219

TABLE 34.

Showing Mean Composition of Fruit from Each Individual Tree for the Season.

SEASON 1917–1918—MARSH'S SEEDLESS.

Tree No.	Average weight per fruit in grams	Average size	Thickness of skin	Per cent skin	Weight of fruit per box	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid
5	481.00	68	9/32	26 21	29,994	48.01	7.57	0.9954	7.6[illegible]
7	599.89	52	9/32	26.86	28,805	35.81	9.78	1.419	6.8[illegible]
9	446.18	64	9/32	28.82	26,498	45 08	8.05	1.197	6.7[illegible]

Weight and size.—Both variable. There is a tendency to increase on the part of the former, while the latter may be considered as practically constant. The increase in weight is shown by the weight per fruit in the tables for individual trees, and by the weights per box given in the table averages. (See tables 33 and 34.)

There are only two instances where a comparison can be made between the weight of fruits of the same size, viz, among the samples picked from tree No. 9 on October 4th and November 12th (see table No. 32), and between the samples obtained on September 21st and December 10th from tree No. 7 (see table No. 31).

In the first instance the fruit with the higher juice content weighed less, while in the second the opposite was true.

Per cent juice.—During this season there has been considerable fluctuations in the per cent juice. If in tree No. 5 (see table No. 30) we compare the per cent juice for fruit with a ratio of less than 7 with that of fruits with ratios between 7 and 8 and fruits with ratios above 8, we find the juice practically constant. In tree No. 7, however (see table No. 31), the fruits with a ratio of 7 or more have a higher juice content than the fruits with ratios below 7, but the reverse is true of tree No. 9, where the fruits with ratios below 7 have the higher per cent of juice. The table of averages for this season, No. 33, shows also a higher content of juice for the fruits with ratios below 7. This may suggest that the Marsh's Seedless begin to attain maturity when they have a ratio of less than 7.

Average of all trees for the season, 41.16 per cent. Highest average, 46 36 per cent, on October 4; lowest, 36.58, on November 12–17.

Per cent skin.—It has not been possible to trace any consistent change in a fixed direction during this season. There has been much fluctuation, and the factor may be considered as practically constant for this fruit within the ratios observed. This is shown both by the individual tree records and by the table of averages for this season

Per cent solids in juice.—This item may be considered as constant for this season within the ratios observed. A mere inspection of the tables will convey this impression. The average for each tree differs very little from the first figure obtained for the season, and in fact, from any other figure in the table. The same is true of the table of averages as the percentages obtained in each case on different dates for a given tree lie as close together as could be expected within the circumstances. Of course, there are notable differences among individual trees. So the average for the season for tree No. 5 was 7.57 per cent, for tree No. 7, 9.73 per cent, and for tree No 9, 8.05 per cent.

The average of all trees for the whole season was 8.67 per cent. The highest average of all trees for any one date was 9.70 on January 10th, and the lowest 8.06 on October 4. Among individual trees the highest per cent obtained was 10.0 per cent for tree No. 7 on October 25th, and the lowest 7.20 per cent for tree No. 5 on December 10th.

Per cent acid.—There is an uninterrupted, notable decrease in acid content all through the season. However, the decrease is much more rapid after a ratio of 7 is approximately reached. The decline really starts when a ratio of 6.5, more or less, is obtained, somewhere around October 25th.

In tree No. 5 the notable decrease occurs on October 25th with a ratio of 7.92. In tree No. 7 the first decline comes after October 25th, with a ratio of 6.64. In tree No. 9 there is a very slight decrease on October 4th, with a ratio of 6.23. The sample for October 25th, was missed, and the next sample picked, on November 12th, shows a notable decrease with a ratio of 7.38. It is not going beyond the limits of a reasonable possibility to suppose that on October 25th a perceptible decrease in acid should have been noticed in this sample.

In the table of averages for all the trees, the decline becomes constant after November 12th–17th, although the samples for October 4th and October 25th, were lower than the first. However, the latter, with a ratio of 7.03, was higher in acid than the former, with a ratio of 6.61.

The average acid content for all the trees throughout the season, was 1.227. The highest average for all the trees at any date was 1.372 on September 21st–23rd, and the lowest, 1.093 on December 10th.

These per cents are higher than those for the same fruit last season, and the average for the season is practically the same as those obtained for the Duncan fruit for the season 1916–17, and 1917–18.

Among individual trees the lowest per cent found was 0.86 on fruit from tree No. 5 on December 10th, and the highest, 1.541, in the sample picked from tree No. 7 on October 25th.

Ratio of solids to acid.—The ratio has increased all through the season, but rather slowly. Two trees failed to make an average of 7 for the season. The ratios very rarely went beyond 7. The one tree which reached an average of 7 did not reach 8. Taking the table of averages of all trees for the season, the first average ratio of 7 appeared on October 25th, just about the date when the decline in acid content started. By the end of the season, on January 10th, the ratio attained the highest average for the season, which was only 7.60.

CONCLUSIONS.

The changes undergone by the Marsh's Seedless grapefruit during this season were much less perceptible than last season's and in many instances were totally absent. As the changes in juice content, per cent skin, weight of fruit, and ratio of solids to acid take place with more intensity while the fruit is yet unripe and is progressing

toward maturity, it is safe to assume that the fruit in this season was very near maturity when the first samples were picked. If this is coupled with the fact that the characteristic decline in acid occurred this season with this fruit when the ratio was about 6.5, and notice is taken of the first average ratio of the season, which was 6.43, it will be seen that there is ample room for the assumption expressed above, and further, to suggest that this variety of grapefruit is capable of reaching maturity with a ratio of less than 7, but quite above 6.

Comparing now the averages for the two seasons, we make the same observations as in the case of the Duncans; that is, the fruit for the season 1917–18 has less juice, more solids, rather higher acid, and practically equal ratio. The sizes are about the same. This was so in the case of the Duncans, as well. The weight per fruit in the case of the Marsh's Seedless, though, was practically the same, only very little higher for the 1917–18 fruit. The figures are presented below.

Season	Weight per fruit	Per cent skin	Thickness of skin	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Average size
1916-17	509.8	30 88	25?64 '	44.94	7.91	1 117	7.08	58
1917-18	511.8	26 87	....	41.16	8.67	1 227	7 09	56

This is indicative of the fact that some fixed cause was acting to produce identical results, and the only one factor in this case that could affect all the trees in approximately the same way was the weather, as this was the only one that was very nearly the same for all of the trees in a given season.

SEASONAL CHANGES OF GRAPEFRUIT, 1918 TO 1919.

As already stated, only Duncan fruit was used during this season. As explained observations were made on the color of the skin, the taste of the juice, and the consistency of the cells. The same system of notation for color as that employed by Mr. Cady was adopted. For describing the taste, the term "tart" as used by Collison[1] was employed, for designating that particular taste which is neither entirely sour nor sweet but which is rather a kind of middle point between these two extremes. Then the words "sour" and "bitter" variously modified have been made to express obvious variations in taste. The juice cells have been described as "well filled" when

[1] Bul. 115, University of Florida Agricultural Experiment Station, "Sugar and Acid in Oranges and Grapefruit," by S. E. Collison.

they have been full of juice, turgescent, well rounded up, and with an even, glossy surface. When this condition has been present, but not to perfection, the terms "filled" and "partially filled" have been employed. In the absence of these properties the terms "dry" and "hard" have been used to describe them.

It was during this season that determinations of nitrogen, phosphoric acid, potash, and ash were made on the whole fruit. However, these data will be given and discussed in a separate section of this work.

Analyses of samples of soil and subsoil taken from around the bese of each tree were again made, and the results are given below.

The trees were again designated by numbers, following the numerical order of the previous year.

TREES SELECTED FOR THIS SEASON'S WORK.

All trees selected were of the Duncan variety, except tree No. 13, which was a Marsh's Seedless.

Manager or owner of grove	No. of the trees	Location	Type of soil
Mr. E D. Stevens	12	Vega Alta	Sandy
Mr. E. D. Stevens	13	Vega Alta	Sandy
Mr. M. L. David	14	Vega Baja	Sandy loam
Mrs. C. D. Smith	15	Vega Baja	Sandy loam
Mr. E R. Day	16	Manati	Clay loam
Messrs. Scoville and Castle	17	Manati	Clay loam
Mr. W. K. Kæhrle	18	Vega Alta	Sandy

COMPOSITION OF THE SOIL.

The analyses of the soils and the corresponding subsoils in each grove are given below—on their water-free basis.

Mr. Stevens' Grove—Trees Nos. 12 and 13.

	Soil	Subsoil
Color	Dark brown	Yellowish brown
Type	Sandy	Sandy loam
Depth of soil	Two feet	....
Depth of subsoil sampled	....	Two feet
Moisture	1.24 per cent	1.50 per cent
Voatile matter	5.84 per cent	5.00 per cent
Insoluble matter	88.68 per cent	81.51 per cent
Nitrogen (N)	0.420 per cent	0.140 per cent
Phosphoric anhydride (P_2O_5)	9.102 per cent	Traces
Calcium oxido (CaO)	None	None
Iron and aluminium as (Fe_2O_3)	5.54 per cent	7.08 per cent
Potash (K_2O)	Traces	Traces

Mr. H. L. David's Grove—Tree No. 14.

	Soil	Subsoil
Color	Reddish brown	Red
Type	Sandy loam	Sandy clay
Depth of soil	Two feet	None
Depth of subsoil sampled		Eighteen inches
Moisture	1.64 per cent	1.46 per cent
Volatile matter	5.61 per cent	6.47 per cent
Insoluble matter	83.48 per cent	81.79 per cent
Nitrogen (N)	0.106 per cent	0.078 per cent
Phosphoric anydride (P_2O_5)	0.114 per cent	0.090 per cent
Calcium oxide (CaO)	Traces	None
Iron and aluminium oxide as (Fe_2O_3)	8.26 per cent	7.19 per cent
Potash (K_2O)	0.0014 per cent	0.008 per eent

Mrs. C. D. Smith's Grove—Tree No. 15.

	Soil	Subsoil
Color	Light brown	Red
Type	Sandy loam	Clay
Depth of soil	Nine inches	
Depth of subsoil sampled		Fifteen inches
Moisture	1.80 per cent	1.70 per cent
Volatile matter	6.26 per cent	8.77 per cent
Insoluble matter	83.59 per cent	78.59 per cent
Nitrogen (N)	0.112 per cent	0.089 per cent
Phosphoric anhydride (P_2O_5)	0.109 per cent	0.106 per cent
Calcium oxide (CaO)		
Iron and aluminium oxides as (Fe_2O_3)	6.52 per cent	9.80 per cent
Potash (K_2O)	00.027 per cent	0.055 per cent

Mr. E. R. Day's Grove—Tree No. 16.

	Soil	Subsoil
Color	Red	Red
Type	Clay	Clay
Depth of soil	Eigh inches	
Depth of subsoil sampled		Twelve inches
Moisture	2.32 per cent	2.90 per cent
Volatile matter	11.81 per cent	9.47 per cent
Insoluble matter	66.09 per cent	67.52 per cent
Nitrogen (N)	0.189 per eent	0.157 per cent
Phosphoric andydride (P_2O_5)	0.180 per cent	0.114 per cent
Calcium oxide (CaO)	0.221 per cent	Traces
Iron and aluminium oxides (as Fe_2O_3)	14.26 per cent	22.99 per cent
Potash (K_2O)	0.048 per cent	0.007 per cent

Messrs. Scoville & Castle's Grove—Tree No. 17.

	Soil	Subsoil
Color	Reddish brown	Red
Type	Clay loam	Clay loam
Depth of soil	Ten inches	
Depth of subsoil sampled		Ten inches
Moisture	1.94 per cent	2.18 per cent
Volatile matter	10.12 per cent	8.08 per cent
Insoluble matter	72.92 per cent	71.82 per cent
Nitrogen (N)	0.195 per cent	0.134 per cent
Phosphoric anhydride (P_2O_5)	0.160 per cent	0.147 per cent
Calcium oxide (CaO)	0.285 per cent	0.221 per cent
Iron and aluminium oxides (as Fe_2O_3)	11.47 per cent	12.00 per cent
Potash (K_2O)	0.025 per cent	0.01 per cent

Mr. W. K. [illegible]'s Grove—Tree No. 18.

	Soil	Subsoil
Color	Dark brown	Red
Type	Sandy	Sandy loam
Depth of soil	Six inches	
Depth of subsoil sampled		Eighteen inches
Moisture	1.15 per cent	1.14 per cent
Volatile matter	5.81 per cent	5.42 per cent
Insoluble matter	87.95 per cent	84.56 per cent
Nitrogen (N)	0.189 per cent	0.124 per cent
Phosphoric anhydride (P_2O_5)	0.134 per cent	0.150 per cent
Calcium oxide (CaO)	0.168 per cent	0.124 per cent
Iron and aluminium oxides (as Fe_2O_3)	3.79 per cent	6.40 per cent
Potash (K_2O)	0.085 per cent	0.058 per cent

These samples were taken with a gage of 4″ diameter.

Physically and chemically we have here two distinct types of soils, as may be seen from the following comparative table, in which the numbers of the trees have been used to differentiate the groves on which they stand.

Tree No.	Insoluble matter	Nitrogen	Phosphoric acid	Potash	Calcium oxide	Ferric oxide	Color
12 and 13	88.68	0.420	0.100	Traces	None	5.54	Brown
14	83.48	0.106	0.114	0.0014	Traces	8.26	Red
15	88.59	0.112	0.109	0.027	None	6.52	Brown
18	87.95	0.189	0.134	0.085	0.18	3.79	Brown
16	66.09	0.189	0.180	0.048	0.22	14.26	Red
17	72.92	0.195	0.16	0.026	0.28	11.47	Red

From the physical point of view, the first four samples are of the same kind, sandy soils, while the last two are clay soils. All except one of the sandy soils are of brown color, while the two clay soils are red.

Chemically, we have a group of soils (which composes all of the sandy soils, except the one corresponding to tree No. 18) which are rather deficient in plant nutrition, and another group, composed of the clay soils plus the sandy soil corresponding to tree No. 18, which are soils of a fair degree of fertility. Moreover, the composition of the different soils in each group agree fairly well if differences of minor importance are waived, so that we can simplify matters by assuming that we have only two kinds of soils to deal with. It is well to keep these facts in mind when we come to discuss the effect of the soil on the composition of the fruit.

COMPOSITION OF THE FRUIT.

INDIVIDUAL TREE RECORDS.

The seasonal changes undergone by the fruit on each tree is shown by the tables that follow.

TABLE 35.

Individual Tree Records.

SEASON 1918–1919.

TREE No. 12—DUNCAN.

Date picked	Average weight in grams	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	Average size	Invert sugar	Cane sugar	Total sugar	Ratio of invert sugar to sucrose	Color	Taste	Consistency of cells
October 28	575.04	11/32"	26.53	30.82	8.94	1.151	7.767	54	....	....	....	....	G. Y. T.....	Tart.	Well filled
November 12	636.29	4/16"	23.59	48.82	8.26	1.065	8.260	34–46	4.080	4.871	8.65	0.921	Y. G.	”	” ”
November 28	541.47	4/17"	24.59	44.10	9 10	1.015	8.965	54	1.977	2.749	5.867	0.719	G. Y.	”	” ”
December 12	[illegible]	9/32"	24.88	47 00	8 80	1.018	8.64	46–64	3.220	3 190	6.58	1.009	Y.	”	” ”
January 2	[illegible]	3/16"	22.86	32.88	9 00	0.9537	10.82	46–54	3.410	2.213	5.94	1.540	G. Y........	”	” ”
January 20	[illegible]	4/16"	26.78	41.78	8.70	0.941	9.24	46	3.480	2.110	5.58	1·649	G. Y.......	”	” ”
February 24	[illegible]	4/16"	24.13	46.428	8.80	0.837	10.51	51	3.970	2.04	6.118	1.946	....	”	” ”
Averages for the season	[illegible].77	1/4	24.41	40.97	8.80	0.9972	8.82	49	3.3478	2.882	5.854	1.405			

TABLE 36.

TREE No. 14—DUNCAN.

Date picked	Average weight in grams	Thickness of skin	Per cent skin	Per cent juice	Per cent juice	Per cent acid	Ratio of solids to acid	Average size	Invert sugar	Cane sugar	Total sugar	Ratio of invert sugar to sucrose	Color	Taste	Consistency
October 28	401.75	[illegible]	25.15	48 00	11.70	1.434	8.15	68	3.818	....	....	....	G. Y. T........	....	Well filled
November 12	317.4	7/32	23 88	48.21	10.5	1.424	7 37	69	5.10	4.895	10.25	1.068	Y.	Tart	” ”
November 26	354.36	[illegible]	24.22	39.50	10.3	1 327	7.76	80	2 244	2.671	5.057	0.840	S. Y.......	....	” ”
December 12	400.92	4/16	32.07	42 26	10.6	1 329	7.98	72	3 88	2.720	6.604	1.408	G. S. Y. T.	Sour	” ”
January 2	411.07	[illegible]	35.76	44.17	9.95	1.071	9 29	80	3 68	2.932	6.717	1.238	G. Y........	....	” ”
January 20	388.37	[illegible]	29.37	42.85	8.85	1.162	7.61	80	3.66	2.340	6.000	1.564	G. Y........	Rather sour	” ”
February 24	488 75	4/16	[illegible]	47.74	9.9	0.8195	12.08	64	3.72	2.510	6.363	1.482	G. Y........	....	” ”
Averages for the season	386.86	7/32	27.05	44.[illegible]	10.26	1.226	8.36	73	3.71	3.010	6.579	1.235			

TABLE 37.

Individual Tree Record—Continued.

SEASON 1918–1919.

TREE No. 15—DUNCAN.

Date picked	Average weight in grams	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	Average size	Invert sugar	Cane sugar	Total sugar	Ratio of invert sugar to sucrose	Color	Taste	Consistency of
October 28	541.71	3/16	25.26	39.61	10.21	1.403	6 93	64	3 72	......	......	......	G. Y. T.	Rather bitterish and acid	Well filled
November 12	513.12	4/16	25.98	42.37	9.7	1.289	7.52	54	3.92	4.256	8.176	0.921	Y.	Tart	" "
November 26	561.31	7/32	26 47	43.62	9.3	1.187	7.83	54	......	2.749	......	......	S. Y.	Sour	" "
December	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
January 2	487.62	7/32	25.76	43.61	9.2	1.096	8.39	60	3.36	2.55	6 045	1.317	Y.	......	Filled
January 20	521.64	9/32	30.24	40.00	9.10	1.007	9 03	57	3.60	2.03	5.737	1.778	Y. S. G. T.	Tart	"
Averages for the season	525.08	7/32	26.74	41.88	9.50	1.210	7.85	58	3.65	2 896	6.699	1.260			

TABLE 38.

TREE No. 16—DUNCAN.

Date picked	Average weight in grams	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	Average size	Invert sugar	Cane sugar	Total sugar	Ratio of invert sugar to sucrose	Color	Taste	Consistency of cells
October 28	419.89	6/16	26.54	29.63	10 94	1.536	7.12	77	......	......	......	......	G. S. Y. T.	Tart	Filled
November 12	416 71	9/32	29.98	39.46	10 7	1.360	7.86	65	3.62	3.860	7.684	......	Y. G. T.	"	"
November 26	393.66	3/16	24.30	42.35	10.2	1.455	7.00	80	......	......	......	......	G. S. Y. T.	Sour	"
December 2	402.57	9/32	32.78	40.44	10 2	1.459	7.00	72	2 07	2.656	4.887	0.779	G.	"	"
January 2	394.04	7/32	26.31	43.42	10.0	1.307	7.65	78	3 83	2.620	6.589	1.461	S. Y.	"	"
January 20	496.96	7/32	30.58	37.64	9.8	1.284	7.63	69	3.88	2.340	6.344	1.615	S. Y.	"	"
February 24	405.40	3/16	26.11	47.13	10.7	1.182	9.05	72	4.75	2.431	6.310	1.958	......	Tart	"
Averages for the season	418.75	8/32	28.07	40.01	10.36	1.369	7.56	73	3.631	2.782	6.77	1 304			

TABLE 39.

Individual Tree Record—Continued.

SEASON 1918–1919.

TREE No. 17—DUNCAN.[1]

Date picked	Average weight	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	Average size	Invert sugar	Cane sugar	Total sugar	Ratio of invert sugar to sucrose	Color	Taste	Consistency of cells
October 28	Fruit too green to be picked at this date; ripe fruit had already been picked.										....	....	....	....	....
November 12	275.00	4/16	36.00	28.57	10.80	1.738	5.92	80	3.62	3.421	7.222	1.058	G. Y.	Sour	Hard dry
November 26	331.10	7/32	28.22	36.25	10.50	1.868	6.23	80	....	....	....	....	G. S. Y. T.	"	Partially filled
December 12	435.73	5/16	21.60	33.79	10.55	1.738	6.08	?	3.19	3.050	6.402	1.045	G.	"	Filled
January 2	396.00	7/32	26.48	33.46	10.55	1.559	6.76	78	3.58	3.760	7.539	0.962	G. Y.	"	"
January 20	402.57	4/16	28.20	32.05	10.45	1.732	6.08	70	3.73	2.734	6.609	1.364	....	"	"
February 24	453.80	4/16	35.55	26.66	11.70	1.474	7.937	62	4.79	2.745	7.68	1.935	G. Y.	"	"
Averages for the season	382.66	1/4	29.34	32.63	10.67	1.683	6.339	74	3.782	3.142	7.088	1.206			

TABLE 40.

TREE No. 18—DUNCAN.

Date picked	Average weight	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	Average size	Invert sugar	Cane sugar	Total sugar	Ratio of invert sugar to sucrose	Color	Taste	Consistency of cells
October 28	438.04	29.82	41.89	8.44	1.173	7.195	77	....	....	....	....	G. S. Y. T.	A little sour	Well filled
November 12	551.20	28.46	41.34	8.55	1.111	7.690	50	2.95	4.103	7.270	0.718	S. Y.	Tart.... ...	" "
November 26	452.17	25.85	44.55	8.30	1.117	7.430	54	6.27	2.212	....	2.848	Y. G	....	" "
December 12	501.77	26.73	45.35	8.50	....	....	64	2.99	2.407	5.529	1.242	G Y.	A little sour	" "
January 2	....	25.00	40.56	8.85	0.9712	8.590	57	2.36	2.725	5.229	0.868	G. Y.	Tart....	" "
January 20	388.66	28.43	42.15	8.25	0.9619	8.576	56	3.18	2.421	5.629	1.818	G. Y.	"	" "
February 24	484.78	26.08	....	8.50	0.911	9.380	65	3.80	1.720	5.610	2.209	G. Y.	"	" "
Averages for the season	494.43	27.14	42.64	8.41	1.041	8.07	60	3.59	2.598	6.325	1.381			

[1] Evidently this tree was picked periodically by the plantation owners, so that the fruit left was always unripe. This tree has not been used in the computation of averages.

The average seasonal changes of the fruit during this season was calculated by averaging all the samples picked on the same date and constructing the table that follows. This table, then, shows the mean composition of the fruit on the dates specified.

TABLE 41.

Showing Biweekly Analyses of Fruits.

Sampled from six different groves, and analyzed immediately after picking. (One of the trees included in these averages was Marsh's Seedless.)

SEASON 1918–1919—DUNCAN.

Date picked	Average size	Per cent skin	Per cent juice	Per cent solids in juice	Per cent citric acid	Ratio of solids to acid	Invert sugar	Total sugar	Cane sugar	Ratio of invert sugar to sucrose
October 28, 1918 ...	490 09	25 91	38.46	9.87	[illegible]	7.509	3.312	...	.....	.....
November 12, 1918..	508 81	26.66	41.72	9.44	[illegible]	7.895	4.040	8.456	4.28	0 955
November 26, 1918..	474 81	24.91	42 98	9 25	[illegible]	8.820	1.960	5 491	2 66	1.787
December 12, 1918...	476.00	28 19	44.38	9.84	[illegible]	7.925	3.085	5.653	2.68	1 171
January 2, 1919 ...	468.9	24.88	42.00	9 16	[illegible]	8.808	3.240	5.980	2.56	1 266
January 20, 1919 ..	502 17	28.40	40.30	9.69	[illegible]	8 366	3.520	5.828	2.36	1 557
February 24, 1919. .	482 57	26 88	45.40	9 76	[illegible]	9.948	[illegible]	5 996	2.15	1 828
Averages for the season	486.95	26.47	45.25	9.587	1.164	8 06	3.298	6.078	2.64	1 544

1918–1919.

DISCUSSION OF RESULTS.

As in the previous seasons the results as presented in this set of tables will now be discussed by topics, and the coincidences, as well as the disparities existing between this season's results and those of previous seasons duly pointed out.

DUNCANS.

1918–1919

Weight and size.—Both these factors show considerable fluctuation, and no definite tendency to either increase or decrease regularly throughout the season. The correspondence of larger weight to smaller juice content in fruits of the same size is again noticeable here.

In tree No. 12 the samples picked on October 28th and November 26th both of size No. 54, show, the former 30.82 per cent juice and a weight of 575 grams per fruit and the latter 44.1 per cent juice and only 541 grams per fruit

In tree No. 13 the samples picked on November 12th and November 29th, both of size No. 54, show 40 per cent and 43 per cent juice respectively, and their corresponding weights per fruit are 615 grams and 542 grams. In the same tree in the samples picked on October 28th, December 12th and January 20th, all of size No. 64, the highest weight per fruit is shown by the first, 564 grams per fruit, and this
In tree No. 14, however, with the fruit No. 80 picked on Novem-
is the sample with the lowest juice content of the three.
ber 26th, January 2nd and January 20th the rule does not hold. This is the first exception of significance encountered.

In tree No. 16 the samples for December 2nd and February 24th, both No. 72, have weights of 402 and 405 grams respectively, with juice contents of 40 per cent and 47 per cent. In tree No. 17 the first two samples, both No. 80, contain the first 28 per cent juice and 275 grams per fruit, and the second 36 per cent juice and 333 grams per fruit. These constitute other exceptions.

It is noticeable that in the last three instance in which the regularity which had been observed so far does not seem to hold the fruits are all very small fruit, Nos. 72 and 80.

Per cent juice.—With the exception of tree No. 14, in all other instances the per cent juice increased as the season advanced. The increase is also shown by the table of averages No. 41. In this table the lowest average was for the samples picked on October 28th, which was 38.46 per cent, while the highest was shown by the samples picked on February 24th, which was 45.40 per cent. The average of all trees for the season was 42.25 per cent, considerably higher than last season's which was 38.97 per cent, but still lower than that for the season 1916–1917, which was 43.57 per cent.

Per cent skin.—There is considerable fluctuation in the per cent skin, both as regards individual trees and in the table of averages. This is in accord with the observations made during the season 1916–1917.

Thickness of skin.—This may be considered constant, with fluctuations. Observations coincide with those for the two previous seasons. Average for the season for each tree usually in the neighborhood of ¼″.

Per cent solids in juice.—In tree No. 12 there are alternate decreases and increases among the succeeding figures, and all but two figures, as well as the average, are lower than the first.

In tree No. 13 there are three increases and three decreases, com-

paring each figure with the one immediately preceeding and immediately following. The average is also lower than the first figure.

Tree No. 14 shows four decreases and one increase. Average lower than first figure.

Tree No. 15 shows a continued decrease, except for the last figure.

Tree No. 16 shows up the same as tree No. 15.

In tree No. 18 alternate increases and decreases within narrow limits are observed. The average is practically equal to the first figure.

The table of averages for all trees for the whole season No. 41, shows the fluctuations noticed among individual trees, with a marked tendency toward the decrease.

The above observations show a tendency of the solids in juice to decrease during this season.

This is not in accord with observations for the two previous seasons, when the solids remained practically constant but with slight tendency to increase. This may be explained on the ground that this fruit was ripe from the start, and the differences noticed are due to sampling.

The average for all the trees for the whole season was 9.387 the lowest average for any date being 9.16 on January 2nd, and the highest 9.87, on October 28th. This is higher than the average for any of the two previous seasons.

Per cent acid.—A mere glance at the figures for acid shows that this factor gets consistently lower as the season advances. The increases are very exceptional, five cases only being observed during the whole season among all the trees. All averages for individual trees are considerably lower than most of the percentages obtained in the succeeding dates they represent. The table of averages for all the trees throughout the season shows an almost continued decrease This supports the view previously expressed at the beginning of this work.

The highest percentage obtained during this season (see table 41) was 1.318 on October 28th, the lowest was 0.961 on February 24th, and the total average was 1.164. This total average is lower than the averages obtained on any of the dates except two.

These observations coincide with those for the previous two seasons. The highest averages almost coincide in all three seasons, being 1.36 in 1916-17, 1.347 in 1917-18, and 1.318 for 1918-19. This also shows a continued decrease from season to season. The lowest

averages do not agree so closely, being, 1.11 for 1916–17, 1.155 for 1917–18 and 0.961 for 1918–19.

The mean were 1.205 for 1916–17, 1.255 for 1917–18 and 1.164 for 1918–19. The figures for this season, then, are the lowest. However, in general the agreement is remarkable.

Ratio of solids to acids.—In spite of the fact that the solids showed a slight tendency to decrease during this season, the ratio of solids to acids has increased. This proves that the solids increased to a certain extent, but failed to increase proportionately so that their percentages fell off a little. However, the proportion of the acids was so much lower, that the ratio of the former to the latter appeared greater on succeeding dates.

Per cent sugars.—An examination of the tables for the individual tree records does not reveal any marked regularity in the change of the sugar content of the fruit. They rather show a marked tendency on the part of sugars to be constant, as with the exception of a few cases the successive percentages do not differ much from each other. This is again another sign that the fruit had quite reached maturity when the first samples were taken. Furthermore, the averages for the individual trees (see table 42) vary between rather narrow limits. The total sugars ranged from 5.854 for tree 12 to 6.879 in tree No. 14. Cane sugar varied between 2.38 in tree No. 12 and 3.01 in tree No. 14, and invert sugars between 3.20 in trees No. 14 and No. 13 and 3.845 in tree No. 16.

Table 41 showing the averages of all trees for the different dates, however, show something different. The total sugars may be taken as constant, but there is a clear, steady decrease in cane sugar, and a very perceptible tendency to increase on the part of invert sugar.

The averages for all the season were 6.078 per cent total sugars, 2.64 per cent cane sugar, and 3.298 per cent invert sugar.

RELATION OF PHYSICAL CHARACTERISTICS TO RATIO OF SOLIDS TO ACID.

Turning now to the observations made on color, taste, and consistency of cells. In tree No. 12 the ratios were all above 8, the samples were all more or less green, with the exception of the one picked on December 12th, the taste in all cases was designated as "tart," and the cells were all well filled. This fruit showed all the characteristics of a perfectly mature fruit except for the color. Notice that a ratio of more than 8 was reached as early as Octob[illegible]8th and that the fruit was yet far from dropping.

Tree No. 13.—All samples showed green more or less. The greenest looking fruit was that picked on October 28th with a ratio of nearly but not quite 8. The taste of this sample was rather bitter, showing that it could yet improve. However, its cells were filled and juicy. All other samples picked from this tree were tart in taste, and had well-filled juicy cells. Again we see that although the color was fairly green, the ratio was way over 7, very nearly 8; from the beginning, being over 8 in all instances except the first.

Tree No. 14.—In this case we have two samples, picked one on December 12th and the other on January 20th, whose juices were sour. The first was rather green, having only a slight yellow tinge, and the second was slightly less than 50 per cent green. Although they had their cells well filled, showing that they were fully developed, yet they could not be considered as good to eat; however, their ratios were over 7 and very near 8. This shows that the ratio of 7 is reached before the fruit has reached complete maturity for this variety.

Tree No. 15.—Notice the first and the third samples picked on October 28th and November 26th respectively. The first sample had not quite reached 7, although it might be passed as having a ratio of 7. Its color was mostly green, having only a yellow tinge, and its taste was bitter and sour. This fruit evidently had not reached maturity and was not fit to eat. This shows that the Duncan fruit does not mature here before reaching a ratio of 7. The fact that its cells were well filled only shows that it was approaching maturity, and that the limit of maturity lies somewhere between the ratios of 7 and 8, and that therefore 7 is the minimum limit allowable. In the second instance the fruit was yet rather sour, although the ratio was nearer 8 than 7.

Tree No. 16.—The samples picked on November 26th, December 2nd, January 2nd and January 20 th vary in ratio between 7 and 7.65. In them all, the green color predominates, the first two being almost entirely green. It may be noticed that the first two have a ratio of just 7. Their cells were filled, but not to perfection, thus lacking another sign of maturity. All of these samples were sour. So we have that the color, the condition of the cells, and the taste of the juice, all bespeak an immature fruit, yet their ratio was not below 7. This proves that this fruit does not mature before a ratio of 7 is reached.

Tree No. 17.—No sample from this tree except the last shows a ratio of 7. This is due to the fact that the fruits were picked as

they matured by the person in charge of the plantation, so that when the samples were picked for analysis, only immature fruit was found on the tree. For this reason this tree has not been used in the computation of averages. All of the samples except the last were sour. None of the samples had their cells perfectly well filled, and the first with the lowest ratio, had its cells especially hard and dry.

Evidently all samples except the last were very immature. This is another instance where fruit with ratios below 7 have shown themselves to be unfit for consumption.

Tree No. 18.—The first and fourth samples, in which the green color predominated were a little sour. However, their cells were "well filled" and "filled" respectively, so that they might be considěred as just on the border line of maturity. The ratio of the first was 7.19. The ratio of the second could not be calculated as the acid determination was spoiled; however, it may safely be assumed to have been over 7. This is further evidence to show that a fruit does not show a ratio of 7 may be regarded as immature. The rest show signs of maturity in their taste and the consistency of their cells, although the green color predominates. Their ratios are well over 7.

To summarize.—There has not been a single instance where fruits with a ratio of less than 7 have shown signs of maturity, regarding as such the color, taste, and consistency of the cells. That is, every fruit with a ratio of less than 7 has been found to be immature.

Every fruit showing signs of maturity have been found to have a ratio of more than 7 and very nearly 8.

The divisory line between mature and immature Duncan fruit, then, seems to lie between 7 and 8, and perhaps nearer 8 than 7.

Turning now to the table of averages of all the trees for different dates we find than the lowest average ratio of solids to acid, 7.509, occurred on October 28th (the first picking of the season), the highest, 9.948, on February 24th (the last picking), and that the average for all the trees for the whole season was 8.06. This is higher than in any of the previous seasons.

The changes that so far have been observed to characterize the process of maturation have been hardly noticeable, if at all, during this season. This may be taken as an indication, that in a general way the maturation of the fruit had come to completion when the

first samples were picked. In a large measure this was so, as a review of the tables and the discussion shows.

This season the fruit contained more juice, and more solids in the juice, and had a higher average ratio than in previous years. This again might show a more perfect state of maturity.

COMPARISON OF TREES.

1918–1919

The mean composition of the fruit for the season for each separate tree, is given below in—

TABLE 42.

Showing Mean Composition of Grapefruit for the Season for Each Individual Tree.

DUNCAN—SEASON 1918–1919.

Tree No.	Average weight in grams per fruit	Average size	Thickness of skin	Per cent skin	Weight of fruit per box in grams	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar	Cane sugar	Ratio of invert sugar to sucrose
12	584.7	49	1/4	24.41	28,653	40.97	8.80	0.997	8.82	3.3478	5.854	2.382	1.405
13	523.5	69	1/4	25.33	36,121	42.25	8.61	1.031	8.35	3.2000	5.9270	2.590	1.235
14	386.8	73	7/32	27.05	28,240	44.23	10.26	1.226	8.36	3.7100	6.879	3.010	1.235
15	525.0	58	7/32	26.74	30,454	41.88	9.50	1.210	7.85	3.6500	6.699	2.896	1.260
16	418.7	73	1/4	28.07	30,868	40.01	10.36	1.369	7.56	3.6300	6.770	2.782	1.304
17 (1)	382.6	74	1/4	29.34	28,316	32.63	10.67	1.683	6.34	3.7820	7.088	3.142	1.206
18	494.4	60	....	27.14	29,655	42.64	8.41	1.041	8.07	3.5900	6.325	2.598	1.381

[1] The samples picked from this tree were all of immature fruit, as the plantation people picked the fruit as it matured, so that only unripe fruit was left on the tree. For this reason these figures were not included in the averages.

Disregarding tree No. 17, we find that all trees had an average ratio of solids to acid higher than 7. Two trees, Nos. 15 and 16, had ratios lower than 8 but much higher than 7. The other trees had all ratios higher than 8, and quite near each other, the largest difference not reaching 0.8.

The thickness of skin, per cent skin, and weight of fruit per box are fairly uniform for most of the trees. The same is true in a large measure as regards the sugars. The greater differences come in the percentages of acid and solids. The highest acid content and percentage of solids correspond to the tree with the lowest ratios of solids to acid (tree No. 17 excepted), tree No. 16. The lowest acid is shown by the tree with the highest ratio, and with the exception of tree No. 14 the percentages of acid get lower as the ratios are higher. Excepting this same tree No. 14, the percentages of juice for the different trees show a fair degree of agreement.

Tree No. 17 is conspicuous among all the others. Its fruit showed less weight per fruit, and smaller size than any other. It also had a higher percentage of skin, acid, and soluble solids, and a lower content of juice and ratio of solids to acid than any other. The color of the fruit was for the most part green throughout the season, the taste of all the samples was sour, and the cells were never "well filled." Evidently every sample picked was immature. These results suggested a number of considerations, chief among which was the one that most of soluble solids, acids included, are manufactured rather early in the season. It is evident that the juice continues to increase and the skin to decrease until maturity is reached. To get an idea as to the correctness of these views the following tests were made:

Three samples of green fruit were picked from the trees of the Station grove. The samples were marked 1, 2, and 3.

Sample No. 1 was composed of 4 fruits with a very pale yellowish color, very scabby and very hard. The cells or juice sacs, however, were fairly well filled, so that the juice could be extracted by hand pressure. This juice was very sour.

Sample No. 2 was wholly green in color, very hard, containing so little juice that only a very few cubic centimeters could be squeezed out when using the strongest hand pressure. This juice tasted sour and bitter.

Sample No. 3.—This fruit was of an intense green color, very hard, not yielding any juice when squeezed with the hand. When extracted with water the extract had a strongly bitter taste.

Sample No. 1 was squeezed and the juice obtained used for the tests to be described, but in samples numbers 2 and 3 which hardly had any juice, the peeled fruits were extracted with an equal weight of water, and the dilution of the extract calculated from the loss in weight of the pulp, the weight of the extract, and the amount of water used. All results were then figured back to undiluted juice. All measurements and determinations already described were performed on these samples, with the following results:

	Sample No. 1	Sample No. 2	Sample No. 3
Size of fruit	3-5/16 inches diameter	3.1 inche diameter	3-5/16 inches diameter
Thickness of skin	3/8 inche diameter	1/2 inche diameter	9/16 inches diameter
Per cent skin	52.63	48.38	58.82
Per cent juice	21.58	11.87	5.91
Solids in juice	10.68	18.06	27.68
Per cent acid	1.415	2.284	2.928
Ratio of solids to acid	7.5	7.30	9.4

The sugars present in these samples may be considered as negligible. A qualitative test of the juice revealed the presence of sucrose, but when polarized after clarification with Horne's dry lead, samples 1 and 2 read less than 0.1 while sample No. 3 did not seem to affect the polarized light at all. As the polarimeter used did not read below 0.1 no estimate of the negligible reading given by the first two samples is presented. These fruits must have been from 3 to 4 months old.

After deleading the clarified juice with sodium oxalate, inverting with hydrochloric acid and neutralizing, the invert reading on the polariscope was negligible for samples Nos. 2 and 3, and gave about 0.4 for sample No. 1. This shows an almost complete absence of sugars in samples 2 and 3, and very negligible amount in sample No. 1. However, the unclarified juices of all three samples gave copious precipitates when treated with an alkaline copper sulphate solution. Calculating the reduced copper to invert sugar, we obtained 24.3 per cent for sample No. 1, 17.44 per cent for sample No. 2, and 19.01 per cent for sample No. 3. Clearly, the fruit was just beginning the elaboration of sugars at this stage of this development. It is presumed that this elaboration continue until full maturity is reached, when inversion of the sucrose accumulated begins.

The conclusion is warranted that the green fruit contains a goodly amount of reducing bodies, probably glucosides, and tannin bodies,

which may be responsible for the bad effects attributed to immature fruit.

The figures further show rather conclusively the following points:

1. Most of the juice is formed toward the latter part of the period of development.

2. The thickness of the skin diminishes gradually after the first stage of development of the fruit, as does also the percentage of skin.

3. Most of the solids, sugars excepted, are formed very early in the development of the fruit.

From the above observations taken together with the other data at hand the conclusion may be reached that at maturity the formation of solids stops, the juice also stops increasing, the percentage of skin and the percentage of acid diminishes, the amount of total sugars remains constant thereafter, and inversion of sucrose and decomposition of invert sugar set in. These changes, then, ought to mark the point of maturity of the fruit. Of course, it would require further work, more detailed in character, to ascertain the true nature of these changes.

All the previous data sufficiently prove that grapefruit here is capable of reaching a ratio of solids to acid in solution in its juice equal to 7, and that their maturity occurs when this ratio or some higher ratio is obtained. There is a possibility, however, of the Marsh's Seedless coming to maturity with a ratio lying between 6.5 and 7.0.

COMPARISON OF VARIETIES.

For the purpose of illustrating the comparisons about to be made of the three varieties of grapefruit tested, three tables are given showing the mean composition of each variety on approximately coincident days of the succeeding years.

These tables were constructed in the following manner: For each variety the analyses of all samples picked on the same or approximately the same day of the month in each month from September to February of the different years involved, were averaged to represent the mean composition of the fruit on the specified day and month. With these data a table was constructed for each variety showing the mean variation of the composition of the fruit during the period of observation. By averaging all the figures thus obtained for the succeeding days, the mean composition of the fruit for the total time of observation was obtained.

TABLE 43.

Showing Biweekly Analyses of Grapefruit from Two Different Groves.

TRIUMPH—Season 1916–1917.

Date picked	Average weight	Average size	Average weight per box in grams	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	Invert sugar	Cane sugar	Total sugar	Ratio invert to cane sugar
September 22	332.	....	....	31.35	24 45	9.80	1.08	9.0	2.93	4.04	7.180	0.725
October 5–6	429.	80	34,320	32 41	28.87	9.60	1.04	9 2	2.44	3.92	6.568	0 520
October 23	340.	64	21.760	30.88	31.31	9.45	0 99	9.5	3 18	3 19	6.539	1.000
November 3	394.5	90	35,505	26.47	33.92	10.10	0.92	10.9	2.81	3.54	6.537	0.790
November 21	324.5	82	26,609	23 64	35.88	10.10	0.91	11.1	3.58	2.39	6.090	1.500
December 8	400.	92	36.807	28.29	35.57	9.80	0.85	11.15	2.77	3.95	6.929	0.700
December 29	388.5	82	31.850	25.39	35 84	10 30	0.73	14.1	3.42	2.81	6.379	1.210
January 19	405 0	66	26,730	32.57	35.12	10.20	0 76	13.4	3.50	2.85	6.500	1.23
February 19	491.	54	26,614	30 93	29 66	9.50	0.70	13.57	3.50	2.74	6.385	1.27
Averages for the season	387.16	76	30,024	29.10	32.41	9.872	0.887	11.12	3.125	3.27	6.568	0.9556
Rate of change	....	....	....	-0.0577	0.579	-0.0333	-0.0422	....	0.0633	0.0333	0.0833	....

TABLE 44.

Showing Average Biweekly Analyses of Fruit for the Seasons 1916–1918.

MARSH'S SEEDLESS.

Date picked	Average weight in grams	Average size	Average weight per box in grams	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	(1) Invert sugar	(1) Cane sugar	(1) Total sugar as invert	Ratio invert to cane sugar
September 21-23	555.5	41	22,775	30.195	41.845	8.465	1.236	6.85	3.50	2.01	5 63	1.741
October 3-6	461.0	55	25,359	28 520	42.210	7.945	1.245	6.38	2.77	2.08	4.97	1.331
October 20 25	496.2	60	29,771	28.435	40.190	8.355	1.238	6.75	2.52	1.48	4.32	1.702
November 3-17	469 9	58	27.254	28.045	39.210	8.315	1.175	7.07	3.01	1.60	4.73	1.88
November 21	476.0	56	26,695	27.440	49.350	7.831	1.067	7.34	3.20	1.57	4.39	2.038
December 8-10	559.75	53	29,667	31.475	42.675	8 330	1.109	7.51	2.59	2.08	4.89	1.298
December 20-29	539.0	55	29.645	33.810	45 510	7.900	1.062	7.44	2.96	1.95	5.08	1.518
January 10-20	550.5	54	29,727	26.575	42.810	8.805	1.195	7.37	3.54	1.60	5.12	2.212
February 9	493 0	64	31.552	33.100	46.970	7.600	1.060	7.17	3.67	1.35	5.14	2.718
February 24	534 0	56	29.904	29.140	49.900	7.200	0.950	7.58	....	....	....	....
Averages for the season	510.56	55	28,234	30.67	44.06	8.07	1.134	7.12	3.079	1.658	4.825	1.857
Rate of change	....	....	....	-0.117	1.271	-0.141	....	....	-0.0633	-0.128	-0.191	....

TABLE 45.

Showing Summary of Biweekly Analyses of Duncan Fruit for the Seasons (1916–17, 1917–18, 1918–19).

DUNCAN VARIETY.

Date picked	Average weight	Per cent skin	Per cent juice	Per cent solids in juice	Per cent citric acid	Ratio of solids to acids	Per cent invert sugar	Per cent total sugar	Per cent cane sugar as invert	Ratio of invert sugar to sucrose	Average size	Weight per box in grams
September 21–25	597.85	26.62	39 98	8.68	1.359	6.39	3.010	5.358	2.23	1.35	51	30,490
October 4–6	573.46	26.89	42.18	8.81	1.334	6 61	2.880	5.510	2.25	1.28	57	32,687
October 25–28	555.84	25.77	41.00	9.09	1.267	7.17	3.147	5.474	2.21	1.42	58	32,238
November 3-17	552 53	25.77	40.10	9.14	1.193	7.66	3.340	6.390	2.90	1.15	54	29,836
November 21-26	528.15	25.59	43.92	8.92	1.210	7.37	2.800	5 220	2 30	1.22	63	33,273
December 8-21	552.42	27.67	42.79	9.21	1.173	7.85	3.118	5.476	2.24	1.39	53	29,278
December 29 to January 2	566.95	26.20	43.94	8.99	1.093	8 22	3 310	5.658	2.23	1.48	59	33,400
January 17-22	559.05	27.68	42.33	8.97	1.174	7.64	3.280	5.407	2.02	1.02	57	31,865
February 15–24	482 57	26 38	45.40	9.76	1.961	9.95	3.930	6.194	2.15	1.83	52	25,098
Averages for the season	552.09	26.51	42.40	9.06	1.196	7 57	3.201	5.603	2.281	1.40	56	30,912
Rates of changes	....	-0.0377	0.602	0.010	-0.0464	0.395	0.102	-0.0929	-0.01	....	....	....

RATE AT WHICH FRUIT REACHED THE LEGAL RATIO OF 7 (RATIO OF SOLIDS TO ACID).

All of the triumph fruits sampled always showed a ratio considerably higher than 7, even though picked quite early in the season. The lowest average ratio noticed was 9, on September 22nd, when the first sample was picked. At the early date already 100 per cent of the fruit had a ratio of solids to acid higher than the legal ratio of 7. The highest ratio was shown by the sample picked on December 29th, which was 14.1, thus attaining a maximum increase of 5.1 in its ratio in the space of 98 days. These data may be best shown in the following:

TABLE 46.

Showing Rate at Which Fruit Approached the Legal Ratio of 7.

TRIUMPH VARIETY—SEASON 1916-1917.

Months and days	Average ratio of all samples picked within days noted on previous column	Per cent of samples found to have a ratio of 7 or more
eptember 22	9 00	100
October 5-6	9.20	100
October 23	9 50	100
November 3	10.90	100
November 21	11.10	100
December 8-9	11 15	100
December 29	14 10	100
January 18	13.40	100
February 8	13 57	100

As seen from the table the development of the ratio may be divided into three periods, for this fruit. From September 22nd to October 23rd, the ratio varied very little, the maximum range of variation being only 0.5, and the average ratio for the two months being 9.23. On November 3rd the ratio increased to 10.9 and stayed there practically another period of two months during which the average ratio was of 11.05. Then on December 29th, the rato jumped up to 14.10, the highest ratio attained during the season, after which no more increases were noticed, but rather slight decreases, ending two months later with a ratio of 13.57, an average of 13.69 for the period. This fruit reaches the highest ratios of all, reaches the legal ratio of 7 the earliest of all, and its ratio increases at the fastest rate.

The opposite extreme is supplied by the Marsh's Seedless variety Notice the table given below:

TABLE 47.

Showing Rate at Which the Fruit Approached the Legal Ratio of 7.

MARSH'S SEEDLESS VARIETY.

Months and days	Average ratios of all samples picked within days noted in previous columns		Per cent of samples found to have a ratio of 7 or more	
	Season 1916 1917	Season 1917-1918	Season 1916 1917	Season 1917 1918
October 21-25	6.74	6.82	33.3%	50%
November 3-21	7.09	7.31	80.0%	66.6%
December 8-29	7.45	7.55	100.0%	100.0%
January 18-24	7.34	7.39	100.0%	100.0%
February 9-24	7.34	....	100.0%	. .. .
Maximum range	0.71	0.73	....	....

The maximum range of variation in ratio during the season was 0.71 for the season 1916–17 and 0.73 during the season 1917–18. The legal ratio of 7 was not attained until some time between November 3rd and 21st, and then only 80 per cent of the fruit in 1916 and 66.6 per cent of the fruit in 1917 came up to the standard. Not until December 8th to 29th did 100 per cent of the fruit come up to the legal ratio. At this time the maximum ratio for the season was reached, which was 7.45 in 1916 and 7.55 in 1917. It should be remarked, however, that in the season 1917–1918, 50 per cent of the fruit had attained a ratio of 7 on October 21st to 25th when in the 1916–17 season only 33.3 per cent of the fruit had attained this ratio within the same dates, thus showing that the fruit matured earlier in 1917–18 than in 1916–17.

Mean between these two extremes we find the Duncan Variety.

TABLE 48.

Showing Rate at Which the Fruit Approached the Legal Ratio of 7.

DUNCAN VARIETY—SEASONS 1916–1917, 1917–1918, 1918–1919

Months and days	Average ratio of all samples picked within days noted in previous column			Percent of samples found to have a ratio of 7 or more		
	Season 1916-1917	Season 1917-1918	Season 1918-1919	Season 1916-1917	Season 1917-1918	Season 1918-1919
September 22-25	6.2	7.28	....	0%	50.00%	....
October 4-28	5.7	7.24	7.51	16.6%	57.00%	100
November 3-21	7.25	7.98	8.30	75.0%	71.40%	100
December 8-29	7.75	8.00	7.92	100.0%	100.00%	100%
January 2-22	7.80	7.74	8.60	100.0%	100.00%	100%
February 24	....	....	9.95	....	....	1.100%
Maximum range	1.60	0.72	2.44	....	. .....	....

It is true that during 1916 to 1917 the legal ratio of 7 was not attained until November 3rd to 21st, as in the case of the Marsh Seedless, but during 1917 to 1918, this ratio was reached as early as September 22nd, when already 50 per cent of the fruit had attained it. Then again the maximum average ratios were higher for this fruit, and the ratio kept on increasing for a longer period of time. The ranges are also wider, during 1916–17 and 1918–19. However, during the two consecutive seasons 1916–1918 both varieties showed 100 per cent legal maturity within the same period of time. The season 1918–19 is exceptional, as it was the driest of all, and as no Marsh Seedless fruit was tested during this season no comparison can be made.

The relation of these varieties to each other in this respect may best be seen from the following table, which shows averages for each variety for definited dates through the consecutive seasons during which they were tested:

TABLE 49.

Showing Rate at Which Fruit Approached the Legal Ratio of 7.

AVERAGE FOR ALL THE SEASONS, 1916–1919.

Dates	Average rate			Per cent averages of fruit with ratio of 7 or more on previously noted dates		
	Duncan	Marsh's	Triumph	Duncan	Marsh's	Triumph
September 21-25....	6.39	6.86	9.0	[1]25.60%	....	100
October 4- 6....	6.61	6.38	9.2	....	.. ..	100
October 20-28...	7.17	6.95	9.5	57.8%	41.6%	100
November 3-26 ...	7.01	7.20	11.0	82.0%	73.3%	100
December 8-29...	7.85	7.48	12.5	100.0%	100.0%	100
January 2-22....	8.13	7.37	13.4	100.0%	100.0%	100
February 9-24 ...	9.95	7.38	13.5	100.0%	100.0%	100

[1] For two seasons only, in 1918 the first sample of fruit was picked in October.

Tests with the Duncan variety have been carried for three seasons; with the Marsh's Seedless through two seasons, 1916–1918, and the Triumph for only one season, 1916–1918.

The maximum ranges as given by this table are 4.5 for the "Triumph," 3.56 for the "Duncan," and 0.62 for the "Marsh." The maximum average ratios attained within the periods specified were 13.5 for the "Triumph," 9.95 for the "Duncan" and 7.48 for the "Marsh." The "Triumph," as already stated, had a ratio higher than 7 from the beginning. The Duncan showed the legal ratio for the first time during the last week of October and the Marsh during the middle two weeks of November. Both in the case of the Duncan and the Marsh 100 per cent maturity was ob-

tained some time during the second and third weeks of December. Notice that the ratios of the Duncan and the Triumph keep on increasing through the season.

The rates of increase of the ratios as well as the maximum ratios attained, are then in the order "Triumph," "Duncan," "Marsh."

According to these results the date of legal maturity of the "Triumph" comes at a very early date, long before September 22nd, while most of the "Duncan" and the "Marsh" mature some time during the month of November—November 3rd and 26th. By December all varieties show perfect maturity.

Acids and solids.—It has been found that the ratio of solids to acids and its rate of increase is greatest for the "Triumph," least for the "Marsh" and medium between these extremes for the "Duncan." As this rate depends upon the rate of change of the solids and acids we will take this up next. The highest percentage of solids in solution is shown by the "Triumph," the next higher one by the "Duncan," and the lowest by the "Marsh"; not only this, but the lowest acid content is also shown by the "Triumph." However, in the "Marsh Seedless" the percentage of acid is higher than in the "Duncan." It appears then that the higher ratios that obtain in the "Duncan" as compared with the "Marsh" are due to the higher content of soluble solids, coupled with a lower acid content.

Now as to the rates of increase. The rate of increase in this, as in all other instances was calculated by finding the differences between the succeeding figures starting with the first, and marking the differences, positive or negative, according as the figure that followed was larger or smaller than the one immediately preceding it with which it was compared. All the positive and negative differences were added together and the difference between the sums, found. This difference indicated, then, the direction of the variation, whether toward an increase or a decrease. As the periods of time between the succesive dates were practically the same, this difference was divided by the number of approximately equal periods covered, and the quotient taken as the mean variation per period. To illustrate, take the column headed "Per cent solids" in table No. 43, page 81. The succesive differences are as follows:

9.6 minus 9.8 = —0.2	9.8 minus 10.10 = —0.3
9.45 minus 9.6 = —0.15	10.3 minus 9.8 = +0.5
10.10 minus 9.45 = +0.65	10.2 minus 10.3 = —0.10
10.10 minus 10.10 = 0	9.5 minus 10.2 = —0.70

The sum of the positive figures is plus 1.15. The sum of the negative figures is — 1.45. The difference between the sums is — 0.30. As there were 7 approximately equal intervals of time between September 22nd and January 18, but the time elapsed from January 18th to February 19th was about twice as large as the others, we may take the whole time as representing 9 approximately equal periods. Dividing, then, 0.30 by 9 we obtain — 0.0333. That is, the solids in general decreased at the rate of 0.0333 per cent every fifteen days (approximately). The figures so obtained will be taken to represent the rate of change of the different items. In the same manner the rate of change of the percentage of acid was found to be — 0.0422. As seen, the acids decreased at a faster rate than the solids, thus giving rise to an increase in the ratios. Notice, besides, that whereas the decrease in the solids occurs only at intervals, the decrease of the acid is continuous and practically without interruption. This makes the increase in the ratios more marked still.

Taking now the "Marsh's Seedless," it will be noticed that both solids and acids seem to diminish, but in this instance the rate at which the acids decrease, 0.0316, is much lower than the rate of change of the solids (— 0.141). Comparing this variety in this respect with the "Triumph" we find that in the latter the rate of decrease of the solids is only about three-fourths as a large as that of the acid, while in the former the solids diminish at a rate which is over four times as large as that at which the acid decreases. In the "Duncan" the rate at which the acid decreases,—0.0464, is practically the same as in the "Triumph," but the solids show a slight increase (at a rate of plus 0.010) instead of a decrease. In spite of this the rate of increase of the ratio of solids to acid in the "Triumph" is larger. This may be accounted for again by the fact that the decrease in acid in the "Triumph" is practically an uninterrupted process (only one increase of 0.03 having been noticed) while in the "Duncan" two increases, one of 0.01 and another of 0. 06 occur. Besides, the rate of decrease of the acid is slightly larger in the "Duncan." These differences in the rates of change of the soluble solids and acid in the different varieties account for the order in which they come to maturity.

Per cent sugars.—The percentage of total sugars is highest in the "Triumph," less in the "Duncan" and least in the Marsh; 6.568 per cent for the first-mentioned variety, 5.603 per cent for the second, and 4.825 per cent for the last. The proportion of total sugars to

total solids varies also in this order, being 0.655 for the "Triumph," 0.618 for the Duncan, and 0.598 for the Marsh. So, then, the chief differences between the first two varieties that might be made to account for the differences in the taste of their juice is the proportion of solids to acid. The "Marsh" differs from the "Duncan" chiefly in the proportion of total sugars to solids, and from the "Triumph" in both the ratios mentioned. This accounts for the superiority of the "Duncan" over the other two varieties, as regards quality of juice. The staleness of the "Triumph" is due to lack of acid, and the rather insipid taste of the "Marsh" may be attributed to lack of sugar; besides, this last variety also has a little less acid than the "Duncan."

Another interesting point of comparison is the proportion of invert sugar to sucrose. The "Triumph" contains nearly as much invert sugar as sucrose, the ratio of the former to the latter being 0.9556, although in some instances this ratio has been as high as 1.50. Next higher in the ratio of invert sugar to sucrose is the "Duncan" with an average ratio of 1.40, and the highest is the "Marsh" with an average ratio of 1.857. The order in which the varieties stand in the other respects considered has been here reversed, with the "Duncan" always occupying the middle position. This high ratio of invert sugar to sucrose in the "Marsh," however, is not due to an exaggerated percentage of invert sugar, but rather to a low percentage of sucrose, of which it contains the least amount, 1.658 per cent. The highest percentage of cane sugar is contained by the "Triumph" variety, with 3.27 per cent, while the "Duncan" again occupies the middle position with a content of 2.281 per cent. In invert sugar the three varieties were about the same, the order being 3.301 per cent for the "Duncan," 3.125 per cent for the "Triumph," and 3.079 for the "Marsh."

Weight and size.—There were variations in weight between somewhat narrow limits for a given variety but these variations were irregular. The sizes, though varying between wider limits, did not show any regularity, either, in their variations. The "Triumph" showed the smallest average size, number 76; and the least weight per fruit, 387.16 grams. The Duncan and the "Marsh" had about the same size, number 56 for the former and number 55 for the latter, while their weight per fruit did not differ very much, being 552.09 grams for the "Duncan" and 510.56 for the "Marsh." The weights per box, however, were rather uniform for the three varieties, 28.234 kgms. (62.115 lbs.) per box for the "Marsh,"

30.024 kgms. (66.052 lbs.) for the "Triumph," and 30.9721 kgms. (68.1'8 lbs.) for the "Duncan." This would seem to indicate that the differences in weight are affected only very little by the variety, and that they are mostly affected by the size of the fruit. This statement as well as the fact that after the fruit is fully developed its weight is not affected by the time of picking may be fully demonstrated by the following data:

Eighty fruits were picked each month from September to January inclusive from each of the trees marked G, E, H, B, D, F. This fruit, which was used in the experiment to detect the changes brought about by sweating to be described further on, was all measured and weighed, and the weights of all fruits of the same size for each separate month were averaged. The averages obtained for the most common sizes were as follows:

Average Weight in Grams per Fruit.

Size	September	October	November	December	January
36	828	682	833	761	.....
46	573	631	626	658	680
54	573	544	562	539	.....
64	517	501	531	500	586

The average weights of all the samples of fruits of the same average size picked on the different seasons were in turn averaged to find the mean weight of each size for each season, and for all the seasons for which it was tested. The results are given below in tabular form:

TABLE 50.

Showing Weight of Fruits in Grams pre Fruit by Seasons and by numbers.

Size of fruit	1916-1917			1917 1918			1918 1919			Averages for all three seasons		
	Maximum	Minimum	Averages	Maximum	Minimum	Averages	Maximum	Minimum	Averages	Maximum	Minimum	Averages
No. 36	1066	718	756	718	667	690	.....	.....	.....	889 5	701 5	728
No. 46	766	566	650	691.8	576.5	847 9	686	556	596	697.8	566.1	631.
No. 54	658	409	554	585.6	468 0	548 8	615	452	545	619 6	441.8	549.
No. 64	658	817	518	510.0	415.0	469.9	564	417	488	577	877.8	488.
No. 72	.....	.....	.....	424.4	891 0	408.9	405	405	408	414.6	895.5	405

These figures have all been obtained from averages of samples containing from 6 to 12 fruits each.

The number of samples considered for each size in each season are as follows:

Size	1916-17	1917-18	1918-19
36	8	2	......
46	58	16	8
54	101	12	12
64	68	8	9
72	......	4	3

The first of these tables shows that the month in which the fruit was picked has not apparently affected the weight of the fruit, while the second table shows the influence of size, which is the most influential factor affecting weight. The scant influence of the variety on the weight per fruit may be seen from previous tables.

Juice and skin.—In all varieties the juice increased perceptibly and the skin decreased very slightly. The rates of changes, however, differed for the different varieties. The "Marsh" showed the fastest rate of increase of juice, as well as the highest juice content of all, 1.274 and 44.06 per cent respectively. Next followed the "Duncan" with a percentage of juice of 42.40 per cent, and a rate of increase of 0.602, and finally the "Triumph," which had only 32.41 per cent juice and a rate of increase practically the same as the "Duncan," 0.579.

As regards percentage of skin the "Marsh" has the highest, 30.67 per cent, as well as the highest rate of decrease, 0.117. Next comes the "Triumph" with a skin content of 29.10 per cent and a rate of decrease of 0.0577, and finally the "Duncan" with only 26.51 per cent of skin and a rate of decrease of 0.0037. This again shows the "Triumph" to be the poorest of the three varieties in quality, as it has much less juice than either the "Duncan" or the "Marsh," and quite as much skin as the "Marsh". The "Duncan" again stands out as the best, as it contains practically as much juice as the "Marsh," and much less skin.

SUMMARY.

We have, than, the folowing prominent points brought out by this comparison:

1. The "Triumph" is the variety attaining the highest ratio of solids to acids, exhibits the fastest rate of increase in this ratio, and reaches the legal ratio of 7 the earliest of all.

2. The "Marsh" matures with the lowest ratio of solids to acids of all, the rate at which this ratio increases is very slow, and it does

not reach the legal ratio of 7 in an appreciable proportion until the latter part of November.

3. The "Duncan" occupies a somewhat middle position between the "Marsh" and the "Triumph" as regards the points of comparison enumerated.

4. The percentages of solids show, in general, a decrease, both in the "Triumph" and in the "Marsh," the rates, however, being faster in the latter. In the "Duncan" this item increases slightly during the process of maturation. The percentage of acids decreases in all three varieties, but at fastest rate in the "Triumph" and lowest in the "Marsh." As to actual percentages of solids in solution the "Triumph" shows the highest, followed by the "Duncan" and lastly the "Marsh." In acid content, however, the order is reversed, the highest being the "Marsh," followed by the "Duncan" and lastly the "Triumph."

5. The total sugars vary in descending order of "Triumph," "Duncan," "Marsh." The relative percentages of sucrose stand again in the descending order already pointed out, while the percentages of invert sugar are very nearly the same in the three varieties. This makes the ratio of invert sugar to sucrose to increase in the above mentioned order of "Triumph," "Duncan," "Marsh."

6. All posible sizes and weights can be found in any variety. The weights per fruit are not as much affected by varieties, as by other factors, especially size. After the fruit has developed to normal size there is no difference introduced in its weight by the time of picking of the fruit.

7. The "Marsh" and the "Duncan" have about the same content of juice, while the "Triumph" has much less than either. The "Marsh" and the "Triumph" rather coincide in their percentages of skin, the "Duncan" having a lesser percentage than either.

CHANGES IN THE PROPORTION OF PLANT-FOOD CONSTITUENTS OF THE FRUIT.

SEASONAL CHANGES.

In the samples of fruit picked during the season 1918–1919 the nutritive ingredients contained by the fruit were determined, as already explained. The tables presenting the results of the analyses are given below. One table has been prepared for each tree, showing the seasonal changes of individual trees in the proportion of these ingredients. By averaging the results for all samples picked

on the same date the mean seasonal variation of the trees tested is given in tabular form. Tree No. 17, whose matured fruit was always picked before samples for analysis were secured, has been excluded from these averages.

INDIVIDUAL TREE RECORDS.

These tables represent the seasonal variations of each individual tree. They were constructed by tabulating the results of the analyses of the successive samples picked from each tree.

In the discussion that follows only the percentages calculated on the whole fruit inserted in the column headed "Original basis" are used for comparison.

TABLE 51.

Nutritive Elements in Grapefruit—Whole Fruit.

TREE No 12—SEASON 1918-1919.

Dates on which samples were picked	Dry matter	Ratio of solids to acids	Phosphoric anhydride		Potash		Nitrogen	
			Dry Basis	Original Basis	Dry Basis	Original Basis	Dry Basis	Original Basis
November 12.....	15.79%	8.260	0 241 %	0.0381 %	0.955	0 1507	....	....
November 26.....	14.46	8 965	0.257 %	0.0370	0 800	0.1160	0.672	0 1000
January 2.....	13.94%	10 320	0.384	0 0490 %	1 033	0 1440	0.781	0 1030
January 20.....	15.00%	9.240	0.368 %	0 0550 %	0 924	0 1390	0.7195	0.1080
February 24 ...	11.31	10,510	0 558	0.0630	1.190	0.1346	0.858	.. ..
Averages	15.10	9.459	.3616	0.04842	0.9804	0.1368	0.5461	0.1036

This table shows higher phosphoric-acid contents corresponding to higher ratios, as well as a gradual increase in this item in each succeeding sample.

There are practically no variations in nitrogen.

The differences in potash are within the limits of error in sampling and analyzing except for the sample picked on November 26.

TABLE 52.

Nutritive Elements in Grapefruit—Whole Fruit.

TREE No 13—SEASON 1918-1919.

Date in which samples were picked	Dry matter	Ratio of solids to acids	Phosphoric anhydride		Potash		Nitrogen	
			Dry Basis	Original Basis	Dry Basis	Original Basis	Dry Basis	Original Basis
November 12......	16.57	8.680	0.285	0 0472	0.720	0.119	0.306	....
November 26......	12.78	8 809	0.260	0.0330	0.900	0.114	0.515	....
January 2......	13.88	8.790	0 307	0 0390	0.979	0.131	0.748	0.1010
January 20......	10.59	8.114	0.392	0.0420	0.856	0 091	0.727	0.0770
February 24......	12.32	8.760	0 476	0.0590	1 0400	0.110	0.900	0.1110
Averages......	13.20	8.58	....	0.04404	....	0.118	....	0.0963

The variations in the ratios are here (See table No. 52) within

rather narrow limits, and a fair degree of correspondence may be detected between ratios and percentages of phosphoric acid, which shows that below a certain minimum difference in ratio the differences in phosphoric acid are not quite so apparent. However, comparing the average ratios and phosphoric acid contents of this tree and the previous one, it is seen that the tree with the higher average ratio has the higher percentage of phosphoric acid.

The potash content shows little variation.

There are fluctuations in the nitrogen. These the writer is inclined to believe that when occurring in one and the same tree are due to difficulties encountered in drying the substance for analysis. In a number of cases the samples were partially charred.

TABLE 53.

Fertilizing Elements in Grapefruit—Whole Fruit.

TREE No 14, LOCATED AT MR. M. DAVID'S PLANTATION, VEGA BAJA SEASON 1918–1919.

Date on which samples were picked	Dry matter	Ratio	Phosphoric anhydride		Potash		Nitrogen	
			Dry Basis	Original Basis	Dry Basis	Original Basis	Dry Basis	Original Basis
November 12.....	16.82	7.870	0.271	0.0456	1.210	0.203	0.469	0.0789
November 26.....	14.58	7.760	0.262	0.0380	0.790	0.115	0.418	....
January 2.....	14.46	9.290	0.357	0 0471	1.224	0.177	0.172	....
January 20.....	12 00	7.610	0 409	0 0490	1.428	0.180	0.817	0.0980
February 24.....	8.69	12.080	0.426	0.0370	1.390	0.120	0 862	0 0750
Averages......	18 31	8.822	....	0.0433	....	0.1500	....	0.0889

No correspondence is here observed between ratios and percentages of phosphoric acid nor is there any regular increase noticed in this item.

The percentage of potash diminished regularly, if the sample picked on November 26th is excepted. It is significant that in every tree the sample picked on this date shows the lowest percentage of potash.

The nitrogen is lower than in the other trees.

TABLE 54.

Fertilizing Elements in Grapefruit—Whole Fruit.

TREE No. 15, LOCATED AT MRS. G. D. SMITH'S PLANTATION—SEASON 1918–1919.

Dates on which samples were picked	Dry matter	Ratio	Phosphoric anhydride		Potash		Nitrogen	
			Dry Basis	Original Basis	Dry Basis	Original Basis	Dry Basis	Original Basis
November 12.....	15.54	7.52	0.284	0.0441	1.240	0.192	0.616	0.0957
November 26.....	12.50	7.88	0.252	0.0320	0.830	0.104	0.660	0.0680
January 2.....	14.06	8.39	0.287	0.0449	1.282	0.178	0.548	0.0710
January 20.....	18.14	9.08	0.362	0.0480	1.107	0.145	0.493	....
Averages......	18.81	8.19	....	0.422	....	0.151	....	0.0682

The phosphoric-acid content is here rather constant, if the second sample is excepted. With this notable exception, slight increases have accompanied the increases in ratio. There has been a slight tendency to increase through the season.

The potash has diminished steadily, while the ratio has steadily increased. The only regularity in this respect is presented by the second sample again.

The nitrogen has decreased.

TABLE 55.

Fertilizing Elements in Grapefruit—Whole Fruit.

TREE No. 16, LOCATED AT MR. E. R. DAY'S PLANTATION, MANATI.

SEASON 1918–1919.

Dates on which samples were picked	Dry matter	Ratio	Phosphoric anhydride		Potash		Nitrogen	
			Dry Basis	Original Basis	Dry Basis	Original Basis	Dry Basis	Original Basis
November 12.....	17.48	7.86	0.271	0.0472	1.150	0.200	0.566	0.0986
November 26....	18 80	7.00	0.200	0 0280	0.760	0.105	0.590	0.0810
January 2.....	14.12	7.65	0.297	0.0419	1.1010	0.1550	0.590	0.0838
January 20....	14 68	7 68	0 342	0 0500	1 0250	0.150	0.556	....
February 24.....	18.00	9.05	0 382	0 0496	1 290	0.168	0.781	0.102
Averages......	14 596	7.838	....	0.0488	....	0.155	....	.0905

The phosphoric acid increases toward the end of the season. Again the second sample is abnormally low. Notice that the ratios, except the last and second, which are extremes, lie fairly close together. No regularity is noticeable in the variations.

The potash is rather constant in the last three samples, and lower than in the first. The sample picked on November 26 was once more exceptional.

There are no great differences among the percentages of nitrogen.

TABLE 56.

Fertilizing Elements in Grapefruit—Whole Fruit.

TREE No. 17, LOCATED AT MESSRS. SCOVILLE & CASTLE'S PLANTATION, MANATI

SEASON 1918–1919.

Dates on which samples were picked	Dry matters	Ratio	Phosphoric anhydride		Potash		Nitrogen	
			Dry Basis	Original Basis	Dry Basis	Original Basis	Dry Basis	Original Basis
November 28.....	14 00	6.28	0.248	0.0340	0 770	0 108	0 674	0.0940
January 2.....	16.80	6.76	0.317	0.0490	....	....	0.840	0.1300
January 20.....	16.28	6.08	0.380	0 0620	1.340	0.217	0 772	0.1250
February 24.....	17.91	7.987	0.352	0.0630	1.210	0.2167	0.855	0.1530
Averages.....	16.638	6.575	....	0.0512	....	0.1980	....	0.1255

No matured samples were picked from this tree, except the last, so that it affords an opportunity to observe the change in immature fruit. The last two samples are higher in phosphoric anhydride than either of the first two, while the potash is lowest in the first, and practically constant in the last two. The nitrogen is considerably higher in the last three samples than in the first. Notice that the fruit of this tree, which was green, had higher percentages of nitrogen, phosphoric acid and potash, than that from either of the other trees.

TABLE 57.

Fertilizing Elements in Grapefruit—Whole Fruit.

TREE No 18, LOCATED AT MR. KACHRLE'S PLANTATION.

SEASONAL VARIATION OF INDIVIDUAL TREES, VEGA ALTA—1918-1919.

Dates in which sample were picked	Dry matter	Ratio of solids to acids	Phosphoric Anhydride		Potash		Nitrogen	
			Dry Basis	Original Basis	Dry Basis	Original Basis	Dry Basis	Original Basis
November 12	15.08	7.690	0.284	0 0426	9.270	0.191	....	....
November 26	12 92	7.480	0 240	0 0310	0.830	0.107	0.682	0.08[illegible]0
Junuary 2	12.94	8 596	0.315	0.0407	....	....	0.557	0.0720
January 20	15 92	8.576	0.336	0 0534	0 870	0.138	0.358	....
February 24	10.31	9 330	0.392	0 0404	....	....	0.569	....
Averages	13.43	8,328	....	0 0416	....	0 145	....	0.080

The sample picked on November 26 shows the lowest content in phosphoric acid and potash. No regular increase or decrease, can be traced in either of the constituents in this table.

From the above tables of individual trees, the following, giving the mean seasonal variation of all the trees tested, was composed:

TABLE 58.

Seasonal Changes in Nutritive Elements in Duncan Grapefruit.

Mean composition of fruit on the dates specified found by averaging the results of the analyses of all samples picked on the same date.

Dates on which samples were picked	Dry matter	Ratio of solids to acid	Phosphoric anhydride P_2O_5	Potash	Nitrogen
November 12	16.196	7.880	0.0441	0.1759	0.0916
November 26	13.496	7.882	0.0331	0.1101	0.0818
January 2	13.891	8.898	0.0488	0.1560	0.0860
January 20	13.546	8.883	0.0495	0.1338	0.0786
February 24	11.126	9.947	0.0495	0.1066	0.0774

All results have been calculated on the whole fruit.

In the above table the phosphoric acid shows a slight tendency to increase, although two irregularities may be noticed on November 26th and January 2nd. Although in a general way the fruit with the higher ratios usually contain higher percentages of phosphoric acid, yet this correspondence does not follow very closely and is only apparent when the differences in ratios are considerable. Thus, although the fruit picked on November 12th had a ratio of 7.88, and that picked on January 2nd had a ratio of 8.838, yet the phosphoric acid of the former is slightly higher than that of the latter. So also the samples picked on January 20th and February 24th had ratios of 8.333 and 9.947 respectively, but their phosphoric-acid contents were the same. However, no sample with a ratio of less than 8 approaches the percentage of phosphoric acid contained by the sample with ratio of 9.947. This item seems to be influenced to a greater extent by the time of picking of the fruit than by the ratio, as may be seen by averaging separately the first three figures and the last three in the foregoing table and comparing the averages obtained.

The gradual descent of the potash as the season advanced is very apparent, the only notable exception occurring in November 26th. For some unaccountable reason all the samples picked on this date, have been uniformly the lowest in the series. In opposition to phosphoric acid, the potash content shows a tendency to be lower in fruits with higher ratios, and in common with phosphoric acid this correspondence is more evident where the difference in ratios is greater.

This statement is supported by data obtained in another experiment, conducted in cooperation with Mr. W. C. Dreier, a very progressive planter of this district. Briefly stated the experiment has consisted in applying potash to a plot, and leaving two plots, one on each side, without any potash for the last five years. A number of observations have been made on the trees and the fruit from these plots, which will be eventually published. For the present purpose, only a series of potash determinations and ratio of solids to acid will be presented here. They follow in tabular form:

Potash in Grapefruit.

DUNCAN VARIETY.

Number of sample	Date fruit was picked	Plot A		Plot B		Plot C	
		Ratio of solids to acid	Per cent potash	Ratio of solids to acid	Per cent potash	Ratio of solids to acid	Per cent potash
1	June 18, 1919	....	0.207	....	0.2810	....	....
2	October, 1919	5.98	0.205	5.67	0.2190	8.00	0.1770
3	January 31, 1920	9.00	0.151	7.50	0.196	4.97	0.2496
4	February 24, 1920	10.28	0.1077	8.40	0.1427	7.00	0.1110
5	March 29, 1920	9.60	0.168	10.50	0.1641	8.00	0.1778
6	May 17, 1920	9.30	0.116	8.00	0.1808	10.00	0.1240
	Averages		0.1591		0.1805		.1678

Plots A and C received no potash. Plot B received potash.

In this table notice that the most unripe fruit contains the highest percentage of potash in each lot, and that with few exceptions the fruit with the higher ratios contain less potash. Again the descent in potash is more apparent where the differences in ratios are greater.

Incidentally it may be noticed that the fruit from the plot which received potash shows up a little more potash than that from the plots receiving no potash. However, the difference is very small.

The nitrogen content of the fruit does not seem to be affected by the time of picking of the fruit although it might be remarked that the last two sets of samples picked showed the lowest averages. There is no well-established relation between nitrogen content and ratio of the fruit except that the tree from which only immature fruit was obtained, with a ratio of 6.575, showed the highest nitrogen content of all.

As regards dry matter in the fruit, it must be borne in mind that these figures represent the dried residue resulting from drying the chopped fresh fruit in a big air oven where uniformity of temperature was hard to attain, and therefore are scarcely comparable. However, they show such a regular gradual fall through the season, that some value may be attached to them. They show evidently that the fruit kept gaining in juice all through the season, and that in a general way the fruit with the higher ratio contained a higher percentage of juice, and softer tissues.

COMPARISON OF TREES.

The composition of the fruit from the different trees showed a fair degree of uniformity as evidenced by the following:

TABLE 59.

Fertilizing Elements in Grapefruit—Whole Fruit.

Averages of each tree for the whole season.

DUNCAN—1918-1919.

Tree number	Dry Matter	Ratio	Phosphoric acid, original basis	Potash, original basis	Nitrogen, original basis
12	14.10	9.459	0.0489	0.1868	0 1086
13	13.20	8.580	0.0440	0.1180	0.0965
14	13.81	8.822	0 0438	0.1500	0.0839
15	13.81	8 190	0.0422	0.1510	0.0882
16	14 59	7.889	0.0438	0.1550	0.0905
17[1]	16.64	6.575	0.0512	0.1980	0.1255
18	13 43	8.220	0.0418	0.1455	0.080
Averages	14.15	8.247	0.0449	0.1518	0 0896

[1] Tree No. 17 was left out of the averages, as the fruit picked from it was all green fruit

The only notable exception is tree No. 17, from which, as explained, all samples picked were immature. This tree, therefore, should not be compared with the rest, from which ripe, matured fruit was always obtained. Desregarding this one tree, then, we find a fairly close agreement in the percentages of phosphoric acid, potash, and even nitrogen. Only two exceptions are worth noticing, and those are the percentage of potash in the fruit from tree No. 13 and the percentage of nitrogen in the fruit from tree No. 12. The dry matter is also in close agreement.

Comparing now the green fruit from tree No. 17 with the rest, we find a ratio much lower than any of the others accompanied by notable higher percentages in all the constituents determined as well as in dry matter. This suggests a lower content of juice in the greener fruit, and lends evidence to the assumption that most of the mineral constituents of the fruit, if not all, are absorbed and incorporated in the fruit in the earlier stages of development, and that the latter part of the development until maturity is reached is taken up chiefly by an absorption of water and changes in the combinations of the elements already absorbed.

The changes noticed are not wide enough, nor regular enough, to justify any further conclusion as to the variations in the plant constituents of the fruit during the process of maturation. A greater number of analyses, and a more extended period of observation are required before any definite facts may be ascertained. It seems safe, however, to assume that after the fruit is developed

very little changes, if any, occur in its mineral composition or its nitrogen content. Perhaps the only ingredient suggesting a regular variation is the potash.

Although the kind of soil and the fertilizer differed for each one of the trees tested, yet the percentages of the different ingredients found for each tree (excepting tree No. 17) agree fairly well. This seems to indicate that these two factors do not affect very prominently the chemical composition of the fruit. As to the effect of soil, we will see further on. As to the effect of fertilizers, we have not enough data of our own. In the paper entitled "Effect of Fertilizers on Oranges" by H. D. Young of the California Experiment Station, which appeared in the *Journal of Agricultural Research*, Vol. VIII No. 4, pages 127–138, the conclusion is expressed that—

> "There was no increase in the amount of either phosphate or potash in the fruit brought about by the quantities applied in this experiment."

To further quote from this interesting paper we may copy the following sentence:

> "The averages from these plots receiving fertilizers are almost identical with those not fertilized."

Our figures, so far as we have gone, are in accord with these conclusions.

SUMMARY OF PART I.

The whole discussion that precedes may be summarized thus:

1. The changes that take place in the fruit during its development, viz., increase in juice content, increase in weight, decrease in the proportion and thickness of the skin, etc., become less and less perceptible, until finally they cease to be perceptible, as maturity approaches.

2. Obvious signs of maturity, such as color of the fruit, condition of the juice cells, taste of the juice, and general appearance, coincide with cessation in the increase of weight and juice, and the decrease in the content of skin, as well as with the decrease in acid content and the increase of ratio of solids to acids; also with the end of the process of sugar elaboration and the beginning of inversion of sucrose.

3. Taking the changes enumerated and the signs of maturity above referred to as criteria to judge the maturity of the fruit, it may be assumed that grapefruit here may not be considered ripe

and fit to eat before the ratio of solids to acids in solution in the juice has reached at least 7. This minimum ratio should be accompanied by the signs of maturity evident on inspection.

4. The changes enumerated above apply in a general sense to the three varieties tested, but the rate at which they proceed and the extent to which they take place differ for each variety. The details of this comparison have been given on page—.

5. The "Duncan" and the "Marsh's Seedless" varieties attain the legal ratio of 7, and ripeness toward the end of the month of November. The "Triumph" variety shows the legal ratio very early in the season, before September, but true maturity is not probably reached until November.

6. The sugars are formed toward the latter part of the development of the fruit, and their elaboration ceases when maturity is attained. After maturity the sucrose suffers inversion, and some decomposition of invert sugar takes place.

7. All of the solids, acids included, except the sugars are formed at a very early stage in the development of the fruit. When the fruit is yet very green, the percentages of solids in solution, and the ratio of solids to acids are very high. With further development of the fruit the percentages of solids and the ratio descend. When the process of maturation begins the ratio increases regularly again, due to a gradual decrease in the acid content until perfect maturity is attained.

8. The fact that the nutritive ingredients in the fruit, viz., nitrogen, phosphoric acid and potash, are in a higher proportion in the green fruit than in ripe or nearly ripe fruit, further confirms the conclusion that practically all of the solids are formed in the earlier stages of development of the fruit.

9. With fruit which is fully developed no regular changes in the content of nutritive ingredients of the fruit could be detected during the seasons. There are indications, however, that the phosphoric acid may be higher and the potash lower in ripe than in unripe fruit.

10. The proportion of nitrogen, phosphoric acid, and potash were rather uniform for the different trees, a fact which suggests that neither the kind of soil nor the kind of fertilizer have much influence on these items, especially the last two. More work is necessary along this line.

[END OF PART I.]

Part II of this work will appear in a subsequent issue of this JOURNAL.

PUBLICATIONS OF THE YEAR (1920-1921).

(PUBLISHED OR IN PRESS.)

Circular No. 26.—Antrax, por Jaime Bagué.

Circular No. 27.—Restricciones Legales al Comercio de Plantas en Puerto Rico, por M. A. Crespo y L. A. Catoni.

Circular No. 28.—The Cultivation of Citrus Fruits in Porto Rico, by F. S. Earle.

Circular No. 29.—La Morriña Negra, por J. Bagué.

Circular No. 30.—El Mejoramiento de Nuestras Siembras por la Selección, por E. E. Barker.

Circular No. 31.—La Renovación del Terreno por Medio de Siembras Intermediarias de Plantas Leguminosas par E. E. Barker.

Circular No. 32.—La Enfermedad de la Raíz en el Café, por J. Matz.

Circular No. 33.—Varios Trabajos (Presentados en la Reunión de Productores y Profesionales Azúcareros celebrada en Río Piedras el 17 de noviembre de 1920).

Circular No. 34.—La Vaquita o "Piche" de la Batata, por J. D. More.

Circular No. 35.—El Cultivo del Cocotero en Puerto Rico, por P. González.

Circular No. 42.—El Muermo, por J. Bagué.

Bulletin No. 24.—Citrus and Pineapple Fruit Rots, by J. Matz.

Boletín No. 26.—Abonos, por R. Vilá Mayo.

Bulletin No. 27.—Plant Inspection and Quarantine Report (1919-20), by L. A. Catoni.

The Journal of the Department of Agriculture, Vol. IV, No. 3.—An Annotated List of Sugar Cane Varieties, by F. S. Earle.

Annual Report of the Insular Experiment Station of the Department of Agriculture and Labor, for the year 1919-1920.

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